

## **FRIEND: key achievements and opportunities in international co-operation**

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**Abstract** This paper introduces the key objectives of the FRIEND (Flow Regimes from International Experimental and Network Data) 2006 Conference (Demuth *et al.*, 2006). These are to review progress, to establish new research priorities and to identify opportunities to increase co-operation with related international initiatives. Understanding natural and human induced impacts on hydrological regimes and predicting both floods and low flows at gauged and ungauged sites continue to be the key FRIEND objectives. FRIEND initially focussed on research, however, capacity building including software and data base development, training courses, the publication of operational guidance and text books and support to MSc and PhD students have now become a major component of FRIEND activities. The paper reviews key FRIEND achievements since its inception in 1985 and advances proposals of how co-operation with allied international programmes may be improved.

**Key words** international co-operation; FRIEND; HELP; PUB; capacity building; networks; hydrological processes; extremes; prediction; forecasting

### **INTRODUCTION**

This paper summarizes some of the key achievements of FRIEND and identifies opportunities for improving co-operation between FRIEND (Flow Regimes from International Experimental and Network Data) and related international hydrology initiatives, specifically HELP (Hydrology Environment Life and Policy), the PUB (Predictions in Ungauged Basins) programme of IAHS, and related WMO initiatives. The paper is presented from a FRIEND perspective and in the context of the current level of activity of FRIEND research and capacity building. A summary of each programme is presented below and a detailed review of FRIEND is presented in Servat & Demuth (2006). The paper concludes with proposals for advancing co-operation between FRIEND and related programmes.

### **FRIEND, HELP AND PUB**

FRIEND was initiated in 1985 as a key part of IHP-III (third phase of the International Hydrological Programme, UNESCO) by a small team of European hydrologists who sought to realise the operational benefits of the extensive databases gathered from representative and experimental basins during the International Hydrological Decade (1965–1974) of UNESCO. A generic scientific objective was to improve the understanding of the spatial and temporal variability of hydrological regimes across different regions of the world and to advance the estimation of hydrological extremes at ungauged sites. More recently a high priority has been given to bridging the gap between research and operational water management (Gustard & Cole, 2002) and in capacity building in developing countries (Meigh & Fry, 2004; Rees, 2004). The FRIEND project has always had a “bottom up approach” with the project being implemented on a regional basis. Research proposals are developed by hydrologists in the region with a steering committee establishing a research and capacity building strategy. Each regional group has elected a co-ordinator who is responsible for maintaining co-operation, motivating participants and identifying funding opportunities. A high priority has always been given to the secondment of staff between countries and organizations and the sharing of data, models and research tools (van Lanen & Demuth, 2002). Most regional groups have scientific sub-projects, for example low flows, floods and large-scale variations and have established a FRIEND database bringing together hydrological data in a region onto a common database platform.

HELP (Hydrology for the Environment, Life and Policy) was established in 1999 (Anderson & Moody, 2004; Bonell, 2004) to improve integrated catchment management through the creation

of a framework for water law and policy experts, water resource managers and scientists to work together on water-related problems. The broad objectives of HELP are to strengthen field-oriented, experimental hydrology using the drainage basin (up to scales  $10^4$  to  $10^6$  km<sup>2</sup>) as the framework. The desire for this programme to be truly “user-driven” requires the active involvement of both policy and facilitating (water and land resource managers) groups to set the policy agenda and ensure the scientific results will benefit societal needs through the revision of policy and management practices. Unlike most FRIEND groups (the exception is Nile FRIEND) implementation is at the basin level. HELP is also a cross cutting theme of IHP-VI.

PUB (Predictions in Ungauged Basins) is an initiative of the IAHS Decade on Prediction in Ungauged Basins and was launched in 2002. PUB is geared towards developing methodologies for assessing and reducing the uncertainty in hydrological predictions (Sivaplan *et al.*, 2003). PUB is implemented through the following six thematic working groups based on a detailed science plan: Basin inter-comparison and classification, Conceptualization of process heterogeneity, Uncertainty analyses and model diagnostics, Data collection approaches, Hydrological theory, and Hydrological models.

## FRIEND: KEY ACHIEVEMENTS AND FUTURE DIRECTIONS

### The growth of FRIEND

FRIEND has been a major programme of the IHP since its inception in 1985. FRIEND is a cross cutting theme of IHP VI and a major achievement is the development over a 21 year period to include active participation from over 140 countries in eight regional groups (Fig. 1). The number of papers published in the five FRIEND conference proceedings illustrate the growth of and development of FRIEND research (Table 1). Papers are allocated to the region which is the subject of the paper, excluding papers with a generic content. The Northern European FRIEND has been most active since the inception of FRIEND. This is due to the longer period for project development, easier access to national and EU research funding and, most importantly, a larger number of research hydrologists in the region. The Table also illustrates the development of other FRIEND groups, notably AMHY from 1993, activities in Africa from 1997, HKH from 2002 and the considerable contribution to the FRIEND 2006 conference from the AMIGO region. Over this period there has been a change in emphasis between research topics. For example, early Northern European contributions were dominated by papers on hydrological process and detailed water balance studies. These are now fewer in number, as a result of the establishment of a series of parallel conferences by the European Research Basin Network. Compared with earlier conferences, FRIEND 2006 has a reduction of papers on low flow estimation at the ungauged site but an increase in papers on regional regime analysis, teleconnections, trends and climate change. Research on groundwater, water quality and ecology has also seen an increase at FRIEND 2006.

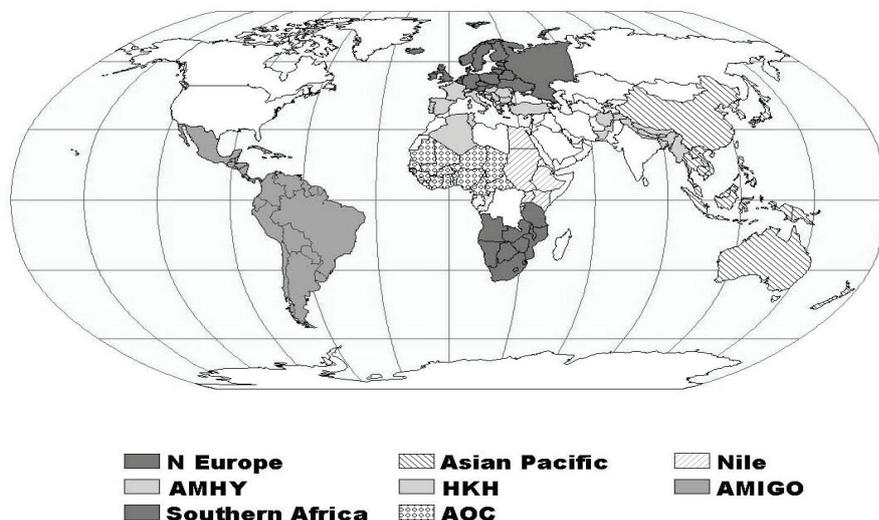


Fig. 1 FRIEND Regional groups.

**Table 1** Distribution by region and topic of papers published in FRIEND conference proceedings in the year shown for the period 1989–2006.

Year	Topic	Number of Papers from each FRIEND region						
		AMHY	AOC	AMIGO	NE	SA	AP	HKH
1989	Data networks and GIS				2		1	
	Water Balance, processes	1	1		10		2	
	Low Flows				8			
	Floods		1		6			
	Precipitation		1		1			
	Trends, telecon, climate variability							
	Groundwater, water quality, ecology							
1993	Data networks and GIS	2			3			
	Water Balance, processes	3			13		1	
	Low Flows				8			
	Floods	2			7	1	1	
	Precipitation	1			1			
	Trends, telecon, climate variability				4			
	Groundwater, water quality, ecology				11			
1997	Data networks and GIS	1				1		
	Water Balance, processes	1			2			
	Low Flows	1			8	1		
	Floods	4			1			
	Precipitation	5	3		1	1		
	Trends, telecon, climate variability	1			4			
	Groundwater, water quality, ecology		2		2			1
2002	Data networks and GIS							1
	Water Balance, processes	1	3		1			
	Low Flows		1		2	3	1	2
	Floods	2	2		4	3	2	
	Precipitation	1	4			1	1	
	Trends, telecon, climate variability	1			5			2
	Groundwater, water quality, ecology		2		4	1		4
2006	Data networks and GIS	3		4	3	1		
	Water Balance, processes		2	7	2			1
	Low Flows	2		2	10			1
	Floods	3		4	3	1		
	Precipitation		3	10		2	1	
	Trends, telecon, climate variability	2		6	12		1	3
	Groundwater, water quality, ecology			9	5		4	1

Data for 2006 is provisional.

Information from Nile FRIEND which held a regional conference in 2005 is excluded.

### The current status of FRIEND

FRIEND research covers a diverse range of topics, including low flows, floods, variability of regimes, rainfall/runoff modelling, processes of streamflow generation, sediment transport, snow and glacier melt, climate change and land-use impacts. The level of activity varies significantly between research groups and over time. These conference proceedings describe FRIEND research covering a wide spectrum of research topics from a diverse range of hydrological regimes. This diversity is illustrated by some examples of FRIEND activities which are summarized below.

In Northern European FRIEND a major activity of the Low Flow group has been the publication of a text textbook on *Hydrological Drought* (Tallaksen & van Lanen, 2004) based on nearly 20 years of cooperative research. The “Large Scale Variation” project is very active in researching hydrological regimes at the continental scale and establishing links between hydrological response and climate (Bower *et al.*, 2004). The main AMHY FRIEND activity was the organization of two international conferences one on the “Hydrology of the Mediterranean and Semiarid regions” and the other on “Climatic and anthropogenic impacts on water resources variability”. These conferences brought together participants from all eight regional FRIEND groups and provided a good model of how co-operation across FRIEND can be enhanced in order to develop capacity for research in developing countries.

Western and Central Africa (AOC) FRIEND now have several projects including low flows and groundwater, the variability of water resources, estimation at ungauged sites and database and website development. Southern Africa FRIEND published a major report on the regions research and capacity building activities (Meigh & Fry, 2004) primarily in the area of water resource modelling and low flow estimation. The Nile FRIEND has been very active, holding four training workshops in Tanzania, Ethiopia, Kenya and Egypt, including low flow and drought analysis and a major international conference in Egypt in November 2005.

In Asia, HKH-FRIEND is working on water resources, floods, deglaciation, and water quality and there is a growing interest in environmental flows and ecosystem health. A new HKH-FRIEND website has been established providing information about the group's activities and is also the Internet platform for the Regional Hydrological Data Centre (Rees, 2004). Asia Pacific FRIEND is planning the publication of a fourth volume of a Catalogue of Rivers in Southeast Asia and the Pacific. The AMIGO group has been active in research on floods, droughts, climate change and eco-hydrology and in extending the project from the Caribbean to the whole of Latin America. Activities across FRIEND groups include developing a common database platform and websites for FRIEND AMIGO, AMHY and AOC regions. Table 2 illustrates the high priority given by FRIEND to capacity building and the transfer of research to the user community with over 28 technical courses being presented in the period 1995–2005, involving 400 participants from over 50 countries.

**Table 2** Technical courses organized by regional FRIEND groups 1995–2005.

Region	Number of courses	Number of countries involved	Total number of participants	Topics
NE	3	10	60	Low flows
AMHY	1	7	25	Low Flows
SA	6	8	90	Data, GIS, extremes, modelling
Nile	3	10	30	Floods, droughts, modelling
HKH	11	10	177	Low Flows, sediments, water quality, glaciers, database
AP	3	20	45	Floods, water resources, low flows
AMIGO	1	12	20	Low Flows

### Future FRIEND research

One of the key objectives of this conference (FRIEND 2006) is to develop a strategy for research for the next five year period. Proposals from each region are presented in Servat & Demuth (2006) and some typical examples of proposed research drawn from the Northern European group are summarized below. The Low Flow group will continue to be active in EU funded research and development programmes including the WATCH (Water and Global Change) project. The objective of the project is to analyse, quantify, predict and evaluate the uncertainties of the components of the current and future global water cycles. The impact of changes in drought frequency on water resources including the energy, industry, agriculture and water supply sectors will be evaluated. The group will also seek to develop the European Drought Centre to improve the coordination and dissemination of drought related research and operational experience in Europe.

The Large-Scale Variations group is developing a programme that includes seasonal river flow forecasting, understanding the impact of climate and land-use change on river basin functioning and publishing a textbook on hydrostochastics—presenting new approaches for interpolation and regionalization. The Extreme Rainfall and Flood Runoff Estimation group will focus on estimating the uncertainty of modelling extreme events. Topics will include estimating design hydrographs of long return periods from flood frequency simulation, using saturated area mapping to improve the performance of the TOPMODEL and using data on snow extent for improved modelling of snowmelt floods.

The Catchment Hydrological and Biogeochemical Processes group will maintain cooperation with the European Research Basin (ERB) group and participate in biannual ERB conferences. Specific research proposals include investigating the relationships between runoff generation

(including water chemistry) and catchment geology, geomorphology, climate, soils, land use and land management.

Although the current phase of the IHP has seen a growth in FRIEND both scientifically and geographically, future proposals for cooperation should be based on a realistic appraisal of the level of activity in the next biennium. In Europe there is continued success in obtaining EU research funds with a change of priority towards coupling hydrological and climate models at the pan-European scale. In contrast, the outlook in the HKH and Southern Africa region is much less encouraging following a reduction in funding from some development agencies. Although UNESCO funding can act as a catalyst for attracting research funds it will not alone be able to support FRIEND. In all regions FRIEND will continue to depend on active support by operational agencies, universities and research institutes. Except for the Nile region, a useful guide to the current geographic and thematic strength of FRIEND is provided by the papers accepted for FRIEND 2006 (Table 1). This indicates those regions where additional resources are needed to develop FRIEND and the more active regions where cooperation with associated international initiatives can be more easily developed, but perhaps is less essential.

## **CO-OPERATION BETWEEN FRIEND AND RELATED INTERNATIONAL PROGRAMMES**

### **HELP**

It is anticipated that any HELP led proposals for joint activities would be welcomed by the FRIEND community, although in many regions the FRIEND and HELP programmes are not active in the same area. There are clear opportunities to integrate current HELP activities in South America in specific basins, e.g. Panama Canal (Panama), Tacuarembó (Uruguay), Jequetepeque (Peru), São Francisco Verdadeiro (Brazil) and Chaguana (Ecuador), with proposed FRIEND research in the AMIGO region. The next HELP International Symposium will be held in South Africa and enable the benefits of focusing FRIEND activities on HELP Basins in the region, e.g. Greater Ruaha (Tanzania), Olifants (South Africa/Mozambique) and Thukela (South Africa) to be discussed. Consideration could be given to a full merger of the two cross-cutting themes in the region in order to optimize the limited financial and staff resources. The conference also provides an opportunity to identify opportunities for pan-African cooperation on HELP basins, e.g. Blue Nile (Sudan-Ethiopia-Egypt), Gash (Sudan-Eritrea-Ethiopia), Nakambé (Burkina Faso) and Upper Ouémé (Benin).

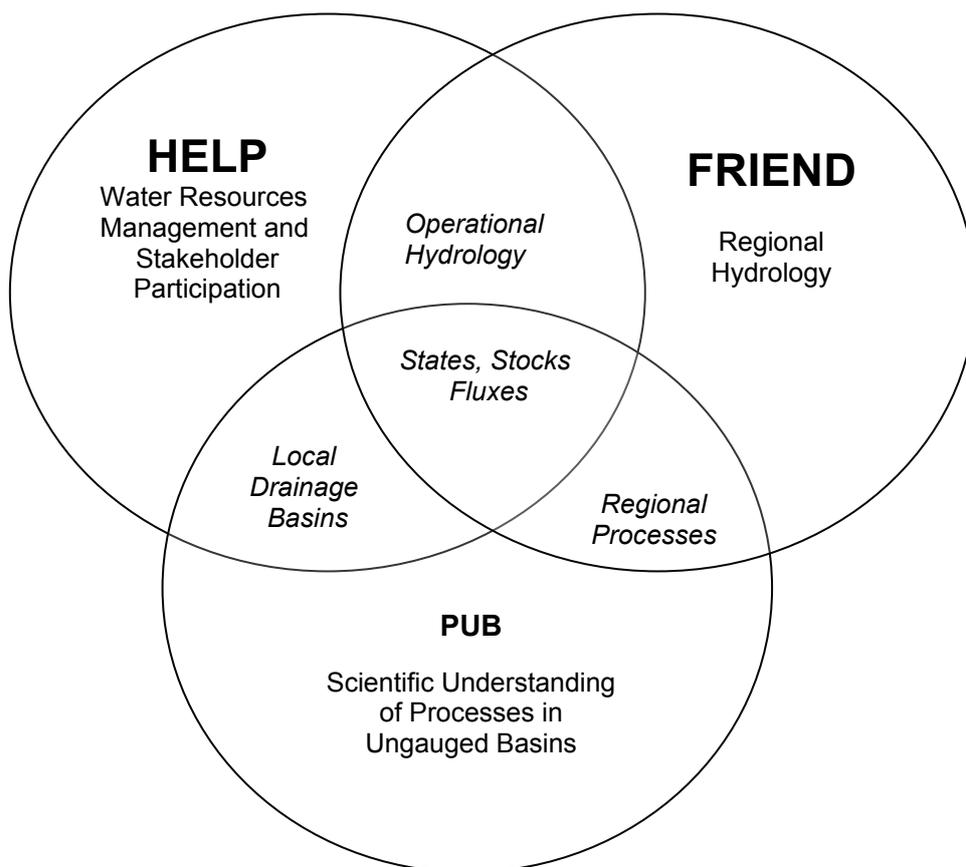
Operational applications of low flow research are most frequently carried out within the framework of national and international law and policy Directives. In Europe the most important of these is the Water Framework Directive (WFD), which has established a strategic framework for the sustainable management of both surface and groundwater resources. Many FRIEND participants are playing an important role in implementing the Directive through the development of national design techniques. In addition, FRIEND has contributed to a consultation document for developing a European drought Policy. These pan-European initiatives provide an opportunity for cooperation with the HELP community and the newly established UNESCO HELP Centre for Water Law, Policy and Sciences.

### **WMO**

A major new WMO initiative is to produce three manuals on: low flows, water resource assessment and flood estimation. This provides an excellent opportunity to establish cooperation between these WMO working groups and FRIEND participants, following earlier examples of cooperation with WMO, including the publication on trend analysis (Kundzewicz, 2004).

### **PUB**

The IAHS programme which has most in common with both FRIEND and HELP is PUB. Following the emergence of the PUB Science Plan in 2003 (Sivapalan *et al.*, 2003), a joint IHP-IAHS (PUB) Technical Liaison Group was established in Koblenz in May 2004 to identify potential synergies between these programmes. Bonell (2006) identified overlaps between these



**Fig. 2** The common intersections of PUB, HELP and FRIEND, (Bonell, 2006).

three global initiatives, summarized potential linkages and highlighted areas where programmes complement each other. All three initiatives have common interests but they each have a unique focus and user community (Fig. 2). Areas for co-operation between FRIEND, HELP and PUB include understanding of processes in pristine basins, watershed classification, comparative model evaluation, prediction of extreme events in ungauged basins under changing circumstances, and new technologies for measuring and monitoring of groundwater.

## CONCLUSIONS

The success of both FRIEND and HELP is indicated by the decision of the Seventeenth Session of the Intergovernmental Council of the IHP held in July 2006 to continue both initiatives as cross-cutting themes in IHP-VII until 2013. This paper has summarized the key achievements of FRIEND, provided some examples of proposed future research and identified opportunities for improved cooperation with the HELP, PUB and WMO programmes. One issue which is common to all programmes and the links between them is the lack of financial resources and experienced man-power to deliver their objectives in most developing countries. The result is that all these initiatives are less well established in these regions and the potential for essential research and capacity building is often not realised. There continues to be a degree of duplication in the objectives of these programmes and it is of concern that new programmes are initiated but the total budget to support them is constant or declining. If the programmes described in this paper are to continue for a further decade then consideration should be given to rationalizing the content of each and holding a major joint conference every four years to improve communication and avoid duplication.

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