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2002-2007

CROSS-CUTTING THEME: FRIEND

Flow Regimes from International
Experimental and Network Data



Northern European FRIEND
Low Flow and Drought Group

**WORK PLAN
2007-2010**

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FUTURE PLANS FOR RESEARCH AND ACTIVITIES IN IHP-VI and IHP-VII

The NE-FRIEND Low Flow and Drought group intends to continue the research work and fruitful cooperation within the framework of the FRIEND project. The current plan covers the last part of IHP-VI, 2002-2007 and the first part of IHP-VII, 2008-2013 (i.e. period between the Havana Conference (25 November - 1 December 2006) and the following FRIEND conference (planned for autumn 2010 in Marakech, Morocco). The work will as in the previous FRIEND period, be organized in smaller groups defined according to specific projects, training activities and research tasks and will in addition, be combined with common meetings and activities.

1. Objectives

The main objectives of the Low Flow and Drought Group are:

- *to promote and encourage regional research on low flow and drought within a consortium of European experts;*
- *to encourage and to carry out training activities on low flow and drought;*
- *to maintain links with other NE-FRIEND groups, Regional FRIEND groups and international groups (e.g. IAHS, WMO) working on related topics;*
- *to encourage new members to take part in the group, in particular younger and female scientists;*
- *to use the FRIEND network to raise funding from international organizations (e.g. EC).*

2. Research topics

The specific research topics will be:

- a- Low flow and drought generating processes and modelling;
- b- Statistics, definitions and indicators;
- c- Regionalization;
- d- Human influences and IWRM.

In addition we will work on:

- e- Transfer of knowledge.

A- Low flow and drought generating processes and modelling

Through physical-based modelling and subsequent analyses better identify and understand the main physical processes that give rise to low flow and drought. Studies will use different types of hydrological models (e.g. distributed, lumped, and comprehensive to simple concepts) and cover different scales (e.g. catchment to river basin and the regional scale). An important aim is to study the propagation of meteorological drought through the subsurface (catchment control), which might lead to soil water drought and hydrological drought (groundwater and surface water) in different hydroclimatological regions (climate control).

Knowledge on low flow and drought generating processes is not only needed for at-site analysis (e.g. outlet of catchment), but it is also essential for understanding of spatial and temporal variability in low flow and drought behaviour. In this context the development and application of methods to characterise the space-time development of droughts at different scales (catchment, regional and Pan-European) will be further elaborated in different hydro-climatological regions. Special attention will be paid to how a drought ceases in a region (e.g. spatial aspects). Figure 1 illustrates the spatial recovery of the severe June-July 2006 drought in the Netherlands.

Knowledge on drought propagation is also a key factor for drought forecasting, i.e. forecasting whether a particular meteorological drought will develop in a soil moisture and/or hydrological drought. Short-term and long-term relief, which is relevant for different sectors, will be addressed.

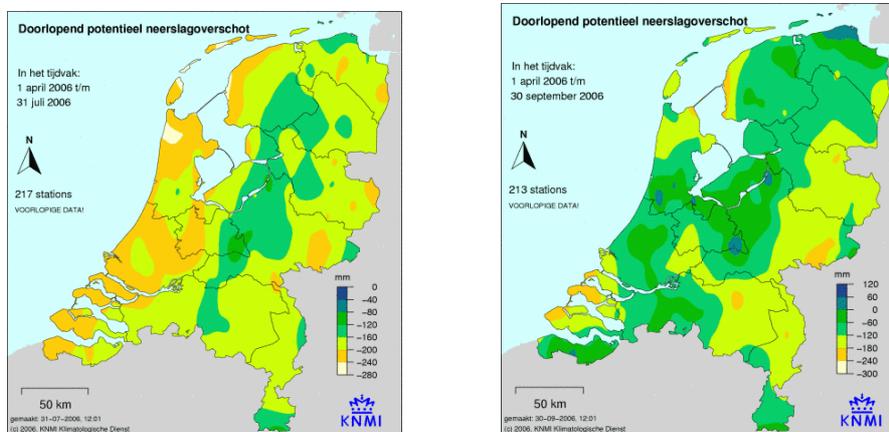


Figure 1 Cumulative difference between the precipitation and potential evapotranspiration since 1 April 2006 in the Netherlands. Left: 31 July, and right: 30 September

B- Statistics, definitions and indicators

This topic will further develop statistical tools to assess low flow and drought, including extreme values. The tools include both at-site and regional approaches and will include also gridded time-series. It will also address uncertainty. The latter will in particular address inadequacies in the observed time series; including the quality of the data itself, the lack of data in certain regions and time periods.

Existing low flow and drought definitions will be further elaborated. This especially applies to groundwater drought definitions (e.g. recharge, heads, storage). Furthermore attention will be paid to include the spatial aspects of a drought in its definition (e.g. area covered by a drought, among others based on gridded data). Increased knowledge on low flow and drought will be used to test the usefulness of existing indicators and to develop new single and multiple indicators. Different sectors and scales will be investigated and links will be sought with water resource stress indicators.

C- Regionalization

Focus will be on further investigation of regional analyses of low flow and drought characteristics, which will likely improve the prediction of the characteristics at gauged sites with rather short time series (extreme value modelling in a regional context). However, the most important aim of the regionalization will be the prediction of low flow and drought characteristics at the ungauged site, including an adequate estimation of the uncertainty. A particular challenge is to improve regionalization approaches in highly heterogeneous areas.

The link between atmospheric circulation, regional precipitation patterns and possible low flow and drought will be studied. Indices representing large-scale atmospheric circulation, air-mass classifications and weather patterns will be included. It is anticipated that the link between atmospheric circulation patterns and low flow and drought will be useful for drought forecasting as an alternative for global/regional climate/weather models.

D- Human influences

Various human activities affect natural low flow and drought. Examples are: climate change, landuse change, water abstraction, urbanisation and large-scale drainage. It will refine and apply existing methods (e.g. statistical, physically-based) to detect changes in hydrological extremes at different scales (e.g. river basin, regional). Additionally the trend detection analysis will deal with the attribution of the various human influences to possible trends in the low flow and drought. Links with the climate community will be explored.

E- Transfer of knowledge

The main transfer of knowledge will be through publications and presentations (oral and poster) at national and international meetings and conferences (e.g. EGU, IAHS, UNESCO, WMO, EC). Student and staff mobility as well as joint student excursions and international training courses are other means of cooperation that have proved useful in the past and will therefore also be encouraged.

In many regions in the world, human activities have enhanced or will enhance low flows and droughts. Usually it is not feasible to easily reduce the negative impact because it will have a detrimental effect on one or more water-related sectors. Hence, it will be explored how knowledge on low flow and drought can contribute to the Integrated Water Resources Management (IWRM) concept similar to the recently published Integrated Flood Management (IFM). It implies the development of hydrological drought characteristics and measures suitable for meeting new European water policies, e.g. the Water Framework Directive. In this context the ecological status of both groundwater and surface water need to be considered.

The European Drought Centre (EDC)¹ will act as a vehicle to transfer knowledge and skills on low flows and droughts between researchers and the user community. It will gather information on current and past droughts in Europe and further act as a meeting place between multi-disciplinary experts in drought research, policy and operational management.

3. Research and training tasks

The research topics will be addressed by specific research tasks that will be carried out by subgroups of the NE FRIEND Low Flow and Drought Group. Some of the subgroups will cooperate with other groups (see "*links*" in Figure 2).

In the context of the 4-year EC Integrated project WATCH (WATER and global Change) that will start in 2007, input will be given on the study of drought generating processes and modelling (topic A, Table 1). The project will involve several members of the NE FRIEND Low Flow and Drought Group. Studies on

¹ <http://www.geo.uio.no/edc/>

drought propagation and how to define the end of a drought will be started through MSc research. Separate research funding will be sought for addressing the important item of drought forecasting.

Table 1 Link between research topics (Section 2) and other international activities

Research topic	WMO	IAHS-PUB	EC-WATCH	EDC
Low flow and drought generating processes and modelling		(+)	+	
Statistics, definitions and indicators			+	
Regionalization		+	+	
Human influences and IWRM			+	
Transfer of knowledge	+	+	+	+

Research on statistics, definitions and indicators (**topic B**) will identify and develop physical indicators for various types of droughts considering different spatial scales, hydrological regimes and water-related sectors. In addition some publications are foreseen (see under tasks under item E).

Research on regionalization (**topic C**) will focus on the prediction of low flow and drought characteristics at the ungauged site, including an adequate estimation of the uncertainty. The study will be linked to the IAHS-PUB (Prediction in Ungauged Basins) initiative. The objectives are: (1) identification of a number of study areas with long time series of hydrometeorological data for low streamflow and hydrological drought prediction around the world, to collate data, and create a database, (2) development and evaluation of stochastic and deterministic methods for predicting low streamflow and hydrological drought characteristics at ungauged

river sites within the study regions, and (3) identification of gaps in our understanding and characterization of low streamflow and hydrological drought processes (e.g. hydrogeological characterization), and advance our current methods and estimation tools to improve low streamflow and drought prediction at ungauged river sites.

In the context of regionalization, research will be carried out on the space-time development of drought (analysis of observed and simulated time series of hydrological variables).

It will be investigated if a large-scale drought study in the Volga and the Danube regions is feasible that contributes to water management during seasonal and multi-year drought.

Possible links between large-scale climate drivers and the temporal and spatial dynamics of hydrological extremes will be identified, including teleconnections and synchronicity of droughts at the regional level. National and bi-national projects (e.g. Univ. of Oslo and University of Birmingham) will also investigate possible links. Research can benefit from links with the NE FRIEND Large Scale Variation Group (theme 3: Large-scale climate-hydrology interaction, incl. teleconnections) and the COST Action 733 Harmonisation and Application of Weather Type Classifications for European Regions, 2005-2010.

The investigation of the impact of human influences on drought (**topic D**) will focus on the attribution of the impact of climate and anthropogenic changes to droughts by comparing trends in observed time series and simulated time series. Efforts are required to collect data on artificial influences.

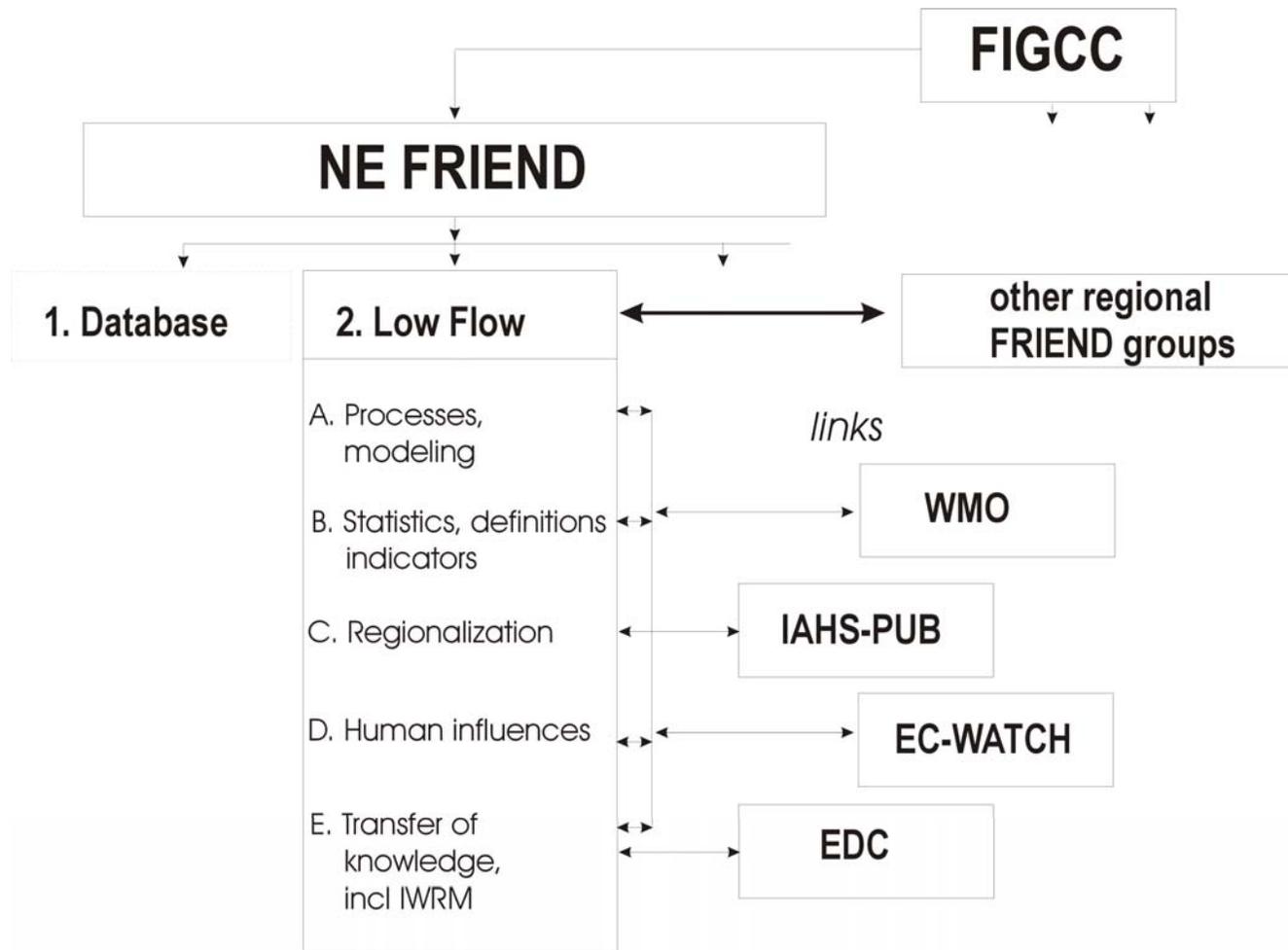


Figure 2 Organizational scheme

In the context of transfer of knowledge (topic E) several technical documents and papers are being compiled and planned. An important document is the WMO Manual on the Estimation and Prediction of Low Flows, editors: Alan Gustard & Siegfried Demuth (see the attachment). It is a state of the art manual for estimating, predicting and forecasting low river flows at sites with and without observational data. The manual will be used by operational agencies for predicting and forecasting low flows for a wide range of applications including national and regional water resource planning, abstraction management, public water supply design, setting in-stream flows, estimating the dilution of effluents, navigation, design of run of river hydropower schemes, design of irrigation schemes and operation of water resources during low flow conditions. The report will enable the hydrological impacts of low flows to be mitigated and will facilitate the design of flow monitoring facilities. The manual will include a worldwide inventory of existing methodologies and legal frameworks on low flow management under drought like conditions and methods of low flow estimation prediction and forecasting. The endeavour would be to survey the available practises and adopt the most suitable practices for various hydro-climatic and hydro-geological conditions. New methodologies will be identified and evaluated. The Manual will address issues such as the scarcity of data including ungauged basins and the implication of land use and climate change. Several members of the NE FRIEND Low Flow and Drought Group contribute to the manual as lead author or co-author.

Scientific papers are being prepared or planned on, e.g. drought propagation in different hydroclimatological regions, drought definitions, and low flows in glaciated areas. An important paper that has been initiated, deals with "Developments in drought trends at the Pan-European scale". This is an update of the study from Hisdal et al. (2001). The paper assumes that the FRIEND EWA is updated. The updated river flow data needed to be stored at GRDC, Koblenz.

Some members of the Low Flow and Drought Group have explored to compile an IAHS-Benchmark paper on Low Flow and Drought, similar to the first Benchmark paper compiled by Keith Beven on *Streamflow Generation Processes*. The IAHS Benchmark Papers in Hydrology Series collects together, by theme, the scientific papers that provided very significant contributions to hydrology in the 20th Century. Being published across a wide spectrum of disciplines, these papers are often unknown and/or inaccessible to younger hydrologists, yet the ideas are as relevant today as then. The Series Editor Jeff McDonnell has been contacted and the group will further discuss how to proceed. It seems that nobody of the group would like to lead this initiative. Other international experts will be approached (e.g. Smakhtin).

Possibilities for a book on droughts in the different hydroclimatological region will be examined as a follow-up of the Elsevier (not a 2nd print). Each chapter would present the special feature of drought regimes (governing climate and catchment control) and include application examples using tools in the Elsevier book (as well as new ones) and operational case studies. Input to this book would be international training courses and workshops as an exchange of information and knowledge.

Papers will be presented at, for instance, EGU, IAHS, UNESCO and WMO international workshops and conferences.

EC funding (e.g. WATCH, Socrates/Erasmus, COST, Marie Currie Actions, see item 4) will be used for staff and student mobility. The excursion of Dutch students to Slovakia is planned to be organized every second year. Other options for excursions will be explored.

Trough the European Drought Centre (EDC) members of the NE FRIEND Low Flow and Drought Group will interact with the scientific and operational communities as well as policy makers and society to raise awareness of the drought hazard and may represent an important platform for future European drought initiatives., e.g. the Water Scarcity and Drought initiative supported by the European Water Directors.

Possibilities to hold an international training course on hydrological drought as in Wageningen (2003), Kuala Lumpur (2005) and Rabat (2006) will be examined. Potential locations are Trieste (Italy), Bhutan, Uzbekistan, South Africa and the Netherlands (Delft, IHE).

Through the EDC, cooperation will be sought with other scientists, operational water management organizations and policy makers on how knowledge on low flow and drought can be incorporated in the Integrated Water Resources Management (IWRM) concept. This should contribute to new European water policies, e.g. the Water Framework Directive. There is a strong emphasis on adaptation on climate change. It will be explored if and how we can contribute to the European Action on Water Scarcity and Drought led by the France, Italy and Spain, which is supported by the European Commission (DG Environment). Possible cooperation also holds for HELP (Hydrology for the Environment, Life and Policy; the other cross-cutting theme in the UNESCO-IHP), the World Climate Programme (WCP), the Natural Disaster Prevention and Mitigation Programme (DPM) and the Drought Management Centre for South-Eastern Europe (Slovenia) from the World Meteorological Organization and the International Working Group on drought risk reduction established as a joint effort between the National Disaster Reduction Centre of China (NDRCC) and the UN International Strategy for Disaster Reduction (ISDR) in Geneva.

Based upon the research and the training tasks the following subgroups have been identified:

- WATCH subgroup;
- FRIEND-PUB IAHS subgroup;
- Volga-Danube subgroup.

4. Budget

The EC Integrated project WATCH that will start early 2007, will provide a major financial contribution to the various research tasks (Section 3). A number of PhD students will be appointed. We anticipate that UNESCO-IHP will support Low Flow

and Drought Group meetings through covering organization costs and travel and subsistence costs for some participants. Possibilities to get funding from COST will be explored. COST is an EC network programme that does not cover staff time. It is planned to submit a proposal early 2007. Other members are encouraged to seek national and international funding, e.g. in the context of the EC 7th Framework programme (Marie Currie Actions). FRIEND and EDC can be used as networks.

5. Meetings and Outputs

Regular sub-group meetings will be organized in cooperation with other international organizations (e.g. IAHS-PUB). Plenary NE FRIEND Low Flow and Drought Group meetings are planned for every 12-18 months. It will be explored to link the plenary meeting to major international conferences or assemblies (e.g. IAHS, EGU, Danube Conference). The possibility of organising common meetings with other FRIEND Low Flow groups will be investigated. The date of a joint meeting with the AMHY Low Flow group in 2008, as a follow-up of the Bratislava meeting in 2004, is being discussed.

As in the previous FRIEND period a technical note describing the general progress of the work, and minutes will be produced in connection with each plenary meeting, and the documents will be available on request or on the web. The coordinator will continuously update a joint list of publication for the group.

ATTACHMENT

MANUAL ON THE ESTIMATION AND PREDICTION OF LOW FLOWS

Contribution to the topic Disaster Mitigation: Floods and Droughts (hydrological aspects)

Revised Guidance Notes 25th July 2006

1. Organisation

Client: WMO Department of Hydrology and Water Resources. Topic: Disaster mitigation: Floods and Droughts

Advisory Working Group (AWG) Leader: Siegfried Demuth, responsible for delivering the project, liaison with WMO, OPACHE and UNESCO; approval by WMO of contents, first draft and final draft; liaising with WMO regarding the contents of related manuals in the series; co-editor and author.

Task leader: Alan Gustard, responsible for preparing draft purpose, scope, contents advising on membership of project team, liaising with lead authors; co editor and author.

Chapter lead author: Is the first named author in each chapter. He/she is an international expert on the topic of the chapter and is responsible for the content and the technical and editorial accuracy of the chapter. The lead author is responsible for liaising with his/her co authors and providing a draft chapter to the Task Leader by agreed deadlines.

Chapter author: to provide material to Chapter lead author by deadlines set by chapter lead author.

All authors and contributors: can contact any lead author if they wish to make a contribution to their chapter. The lead author will decide whether or not they accept or edit the contribution.

External Reviewers: to be appointed by WMO and to comment on the contents and accuracy of each chapter, identifying important errors or omissions but not revising structure of the manual or adding to the agreed contents and scope.

WMO: To decide presentational style and to edit the text, tables, figures, and layout submitted by the AWG leader and produce camera ready copy and organise printing and distribution.

2. Background

The Manual will be published in a new series of WMO publications consisting of several manuals and guidelines within the WMO Quality Management Framework in Hydrology. The manuals will have a practical approach and will address practical aspects as opposed to an academic or theoretical approach and are targeted to

meet the needs of National Hydrological and Meteorological Services. These manuals will include theoretical information only when it is needed for a better understanding of the subject. It is anticipated that the following manuals will be published: the Manual on Flood Forecasting, the Manual on Probable Maximum Precipitation/Probable Maximum Flood, the Manual on Low Flow Estimation and Prediction and the Manual/Guide on Water Resources Assessment. However it has been agreed that the manual on the " Estimation and Prediction of Low Flows will be a free standing manual with general references to the other manuals in Chapter1 "Introduction". These manuals will complement the information available in the Guide to Hydrological Practices and in the WMO Technical Regulations. The "Guide to hydrological Practices" which is now in its fifth edition and under revision was first published in 1965. The latest edition (1994) does have a section on "Low flows and droughts" but although 735 pages long low flows are described in only 6 pages, with 6 references. Reference should also be made to HOMS, the WMO system of technology transfer in the area of hydrology and water resources will be made whenever appropriate. The terminology will also be consistent with the UNESCO/WMO International Glossary of Hydrology

3. Objectives and contents:

The key objective is to publish a state-of-the-art manual for estimating, predicting and forecasting low river flows at sites with and without observational data. The manual will be used by operational agencies for predicting and forecasting low flows for a wide range of applications including national and regional water resource planning, abstraction management, public water supply design, setting in-stream flows, estimating the dilution of effluents, navigation, design of run of river hydropower schemes, design of irrigation schemes and operation of water resources during low flow conditions. The report will enable the hydrological impacts of low flows to be mitigated and will facilitate the design of flow monitoring facilities. The manual will include a worldwide inventory of existing methodologies and legal frameworks on low flow management and methods of low flow estimation prediction and forecasting. The Manual will also address issues such as the scarcity of data including ungauged basins and the implications of climate change. Current practices will be reviewed and the most suitable practices for different hydrological and hydro-geological regimes will be recommended. Where appropriate new methodologies will be identified and evaluated. The market is primarily for operational agencies in developing countries.