Euro-limpacs

Project no. **GOCE-CT-2003-505540**

Project acronym: **Euro-limpacs**

Project full name: **Integrated Project to evaluate the Impacts of Global Change on European Freshwater Ecosystems**

Instrument type: **Integrated Project**

Priority name: **Sustainable Development**

Deliverable No. 11
Report on collated long-term hydrological, meteorological and limnological data from key sites

Due date of deliverable: January 2005 (Month 12)
Actual submission date: January 2005

Start date of project: **1 February 2004** Duration: **5 Years**

Organisation name of lead contractor for this deliverable: **UIBK**

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level (tick appropriate box)		
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

1 INTRODUCTION

In this report we provide a descriptive overview of the long-term data at key sites of Euro-limpacs, which have been collated by all partners collaborating in Task 2.1 of Workpackage 1, i.e. NIVA, SYKE, HBI-ASCR, HSCU, CNR and UIBK.
Task 2.1 deals with the potential impact of changing air temperature and precipitation on catchment mass fluxes. We will use existing meteorological, hydrological and limnological data together with data on atmospheric deposition, and we will use data from climate scenario models to evaluate how the components of the water cycle and catchment mass fluxes respond to past and predicted future changes in regional climate. We will focus on long-term trends, seasonal shifts and on the frequency and magnitude of extreme events, like floods or droughts.

2 COLLATED DATA

Thirteen sites have been selected (Table 1) covering contrastring climate and catchment characteristics. The data collated by the individual partners are described in the following section.

Table 1. Selected key sites and their geographical position, catchment area, minimum and maximum elevation within the catchments, and responsible partners.

Site	Latitude	Longitude	Area (km²)	z_{MIN} (m)	z_{MAX} (m)	Partner
Kårvatn	62°47´N	8°53´E	25	200	1375	NIVA
Valkea-Kotinen	61°14´N	25°04´E	0.30	150	190	SYKE
Hietajärvi	63°10´N	30°43´E	4.64	165	214	SYKE
Plesne Lake	48°47´N	13°52´E	0.67	1090	1378	HBI-ASCR
Certovo Lake	49°10´N	13°12´E	0.86	1030	1343	HBI-ASCR
Starolesnianske pleso	49°11´N	20°10´E	0.03	1986	2030	HSCU
Ladove pleso	49°11´N	20°10´E	0.14	2057	2350	HSCU
Dlugi Staw	49°14´N	20°01´E	0.66	1784	2301	HSCU
Piburger See	47°10´N	10°50´E	1.7	913	2400	UIBK
Lago Paione Superiore	46°10´N	8°11´E	0.50	2269	2661	CNR
Lago Paione Inferiore	46°10´N	8°11´E	1.26	2002	2661	CNR
Lago Boden Superiore	46°26´N	8°27´E	0.30	2343	2952	CNR
Lago Boden Inferiore	46°26´N	8°27´E	0.91	2334	2952	CNR

2.1 NIVA

NIVA has compiled the long-term data for the calibrated catchment at Kårvatn (Table 1) for subsequent analysis of episodic, seasonal and long-term trends. The data include meteorological records, precipitation chemistry, runoff chemistry and discharge.

Data type	Operater	Data from	Monitoring programme
Meteorology	Met.no	1970	Met.no
Precipitation and air chemistry	NILU	1978	EMEP and SFT
Runoff discharge	NVE	1978	SFT
Runoff chemistry	NIVA	1978	SFT

Meteorological stations near Kårvatn are operated by met.no (www.met.no): Observation period of daily precipitation (RR), degree of snow cover (SD), snow depth (SA) and temperature (TAM). Periods with interpolated daily temperature data.

Station	M a.s.l.	Parameters	Observed RR, SA, SD	Observed TAM	Interpolated data
63580 Ångardsvatnet	596	RR, SA, SD	1970-2003		1970-2003
63420 Sunndalsøra	6	TAM, RR, SA, SD	1970-2003	02.1983-2003	01.1970-01.1983

Parameters derived by met.no from daily temperature values (TAM), daily precipitation values (RR), daily snow depth values (SA) of daily degree of snow cover values (SD).

Parameter	Criterion	Derived from
Temperature: weekly, monthly, yearly		TAM
Precipitation: weekly, monthly, yearly		RR
Snow depth: weekly, monthly		SA
First date with the degree of snow cover =4	First five days with SD = 4 continuously	SD
First data with snow depth =0 cm	First five days with SA = 0 continuously	SA
Number of days with bare frost.	SD=1 or SD = 2 and TAM<0 °C	SD, TAM
Melting periods within the winter period	Number of days between the start (SD=0) and end (SA=0) of the winter period	SD, SA
Growing season, start	First five days with TAM > 5 °C continuously	TAM
Growing season, end	First five days with TAM < 5 °C continuously	TAM
Growing season, length	Number of days between start and end of growing season	TAM
Growing degree-days (GDD)	The accumulated degree sum above a threshold temperature, 5 °C within the growing season	TAM
Summer draught, monthly	The Palmer is a soil moisture algorithm calibrated for relatively homogeneous regions	RR

Details on the EMEP station for *precipitation and air chemistry* operated by NILU (from www.nilu.no/projects/ccc):

Name	Code	Database code	Geographical coordinates	EMEP coordinates (50 km)	M a.s.l.	In operation since
Kårvatn	NO39	NO0039R	62º 47'N, 8º 53'E	80.68, 77.50	210	February 1978

Parameters measured by NILU on *precipiation and air samples* taken daily at Kårvatn:

Precipitation: amount, pH, SO_4*, NO_3, NH_4, Ca, K, Mg, Na, Cl

Air: SO_2, SO_4, NO_2, NO_3+HNO_3, NH_3+NH_4, Mg, Ca, K, Cl, Na

Parameters measured by NIVA on *runoff samples* taken weekly at Kårvatn:

pH, conductivity, Ca, Mg, Na, K, NH_4[a], Cl, SO_4, NO_3, Al-species[b], TOC, tot-N[c], tot-P[d]

([a]series incomplete, [b]starting 1984, [c]starting 1988, [d]only a few years)

Acronyms:

Met.no: The Norwegian Meteorological Institute
NILU: Norwegian Institute for Air Research
NVE: Norwegian Electricity and Water Resources Board
NIVA: Norwegian Institute for Water Research
EMEP: Co-operatative Programme of Monitoring and Evaluation of the Long-range Transmissions of Air Pollutants in Europe
SFT: Norwegian Pollution Control Authority

2.2 SYKE

Meteorological, hydrological and limnological data have been collated from the sites Valkea-Kotinen and Hietajärvi (Table 1) (Bergström et al. 1995).
Daily air temperature and precipitation observations are from nearby Finnish Meteorological Institute weather stations, Lammi 1403 on Valkea-Kotinen and Lieksa 3904 on Hietajärvi. *Stream water samples* have been taken since 1989 from gauging weirs installed just below the catchment boundary and, in the case of Hietajärvi, also on the Kelopuro stream. Grab samples for chemical analysis were taken weekly during the spring (snowmelt) peak runoff period, once a month during summer, and bimonthly during autumn. *Runoff* has been continuously recorded with a chart limnograph and daily averages calculated from 1990 onwards. *Runoff scenarios* have been generated with the watershed forecasting and simulation system WSFS (Huttunen and Vehviläinen 2001) using the method of delta perturbation, in which the changes in air temperature and precipitation given by each climate change scenario (Echam_A2, Echam_B2, Had_A2, Had_B2 ; 2071 - 2100) are used to alter daily values of temperature and precipitation of the reference period (1961-1990) fed into the watershed simulation system.

In order to get background and input data for both the time series analysis and the development/application of models for predictions of climate change impacts on element leaching (WP1 Tasks, 2.1, 3.3 and WP4), data on the *carbon (and nitrogen) pools and fluxes* have also been collated from both catchments. The aim in the first phase is to document these results for the Hietajärvi site. Main ecosystem pools and mean annual fluxes are estimated.

Valkea-Kotinen	Site of measurement	Parameter	Data series
Meteorology	Lammi 1403 (Finnish Meteorological Institute)	Temperature (daily) Precipitation (daily)	1.1.1965 - 31.12.2004
Runoff	Gauge weir at lake-outflow (Finnish Environment Institute)	Discharge (daily)	1.1.1990 - 31.12.2003
Water chemistry	Lake (Finnish Environment Institute)	TIC_IR (92), CODMn(383), TOC_IR(125) and others	03.1983 - 10.2004
	Lake in (Finnish Environment Institute)	TIC_IR (81), CODMn(84), TOC_IR(82) , major ions, pH	03.2000 - 10.2004
	Lake out (Finnish Environment Institute)	TIC_IR (185), CODMn(330), TOC_IR(271), major ions, pH	03.2000 - 10.2004
Runoff scenarios		Runoff (daily) in [mm/d]	1.1.2071 – 31.12.2100
Atmospheric deposition	Kotinen (Finnish Meteorological Institute)	Bulk deposition (weekly) NO3N, NH4N, SO4S, Mg, Ca, K, Na, Cl, pH, As, Cd, Cu, Fe, Mn, Ni, Pb, V, Zn	1.4.1987 - 31.12.2003

Hietajärvi	Site of measurement	Parameter	Data series
Meteorology	Lieksa 3904 (Finnish Meteorological Institute)	Temperature (daily) Precipitation (daily)	1.1.1970 - 31.12.2000
Runoff	Hietapuro – outflow of Iso-Hietajärvi (Gauge weir) (Finnish Environment Institute)	Discharge (daily)	1.1.1988 - 31.12.2003
	Kelopuro – inflow of Pieni Hietajärvi (Gauge weir) (Finnish Environment Institute)	Discharge (daily)	1.1.1988 - 31.12.2003
Water chemistry	Hietapuro (Finnish Environment Institute)	TOC_IR(335), major ions, pH	05.1988 - 04.2004
	Kelopuro (Finnish Environment Institute)	TOC_IR(335), major ions, pH	05.1988 - 04.2004
Runoff scenarios		Runoff (daily) in [mm/d]	1.1.2071 – 31.12.2100
Atmospheric deposition	Hietajärvi (Finnish Meteorological Institute)	Bulk deposition (weekly) NO3N, NH4N, SO4S, Mg, Ca, K, Na, Cl, pH, As, Cd, Cu, Fe, Mn, Ni, Pb, V, Zn	1.11.1987 – 31.12.2003

At both sites *calculation of carbon pools and fluxes*:

Pools: Lake water and lake sediment

Annual fluxes: Deposition, forest net photosynthesis (modeled values), lake sedimentation, runoff water and primary production in lake (only for Hietajärvi)

References

Bergström, I., Mäkelä, K. and Starr, M. (Editors), 1995. Integrated Monitoring Programme in Finland. First National Report. Ministry of the Environment, Environmental Policy Department, Report 1. Helsinki, 138 (+3 appendices) pp.

Huttunen, M. and Vehviläinen, B. 2001. The Finnish watershed simulation and forecasting system (WSFS). In: J. Kajander and E. Kuusisto (Editors), Northern Research Basins. 13th International Symposium & Workshop, Saariselkä, Finland, Murmansk, Russia, August 19-24, 2001. Finnish Environment Institute, Helsinki, pp. 41-50.

2.3 HBI-ASCR

HBI-ASCR has collated data for two lakes in the Bohemian Forest: Plešné Lake and Čertovo Lake (Table 1).

Plešné Lake	**Site of measurement**	**Parameter**	**Data series**
Meteorology	Lake (automatic weather station)	Temperatur (15 min readings) Precipitation (15 min) Humidity (15 min)	10.1999 - 01.2005
Hydrology	Lake outflow (gauge with permanent registration)	Discharge (15 min) Water temperature (15 min)	10.1999 - 01.2005
Atmospheric deposition	Lake level and uppermost part of catchment	9 Throughfall samplers 2 Samplers (open area)	05.1997 - 01.2005
Water chemistry	Lake 4 Lake tributaries	SO_4-S, N-forms, Si, P, Al, Fe, Ca, Mg, Na, K, Cl, DOC (monthly)	10.1999 – 01.2005
Čertovo Lake	**Site of measurement**	**Parameter**	**Data series**
Meteorology	Lake (automatic weather station)	Temperatur (15 min readings) Precipitation (15 min) Humidity (15 min)	11.1997 - 01.2005
Hydrology	Lake outflow (gauge with permanent registration)	Discharge (15 min) Water temperature (15 min)	11.1997 - 01.2005
Atmospheric deposition	Lake level and uppermost part of catchment	9 Throughfall samplers 2 Samplers (open area)	05.1992 - 01.2005 (1997 only annual values)
Water chemistry	Lake 7 Lake tributaries	SO_4-S, N-forms, Si, P, Al, Fe, Ca, Mg, Na, K, Cl, DOC (monthly)	10.1997 – 01.2005

It is planned to extend most studies until December 2008, depending on the availibility of funding (present national project funding this study will end in Dec. 2005 and EURO-LIMPACS funds are sufficient to continue by the end of 2006).

Long-term meteorological data are available from Churáňov meteorological station (Czech Hydrometeorological Institute), situated in the central part of the mountain area ~50 km east of Čertovo Lake:

Site	Geographical coordinates	M a.s.l.	Parameter	Data series
Churáňov	49°04' N, 13°37' E	1122	Temperature (7, 14, and 21 hours) Precipitation (daily) Humidity (daily) Wind velocity and direction (daily) Cloud cover (daily) Sunshine duration (daily)	1961-2004

Reconstruction of air temperature data: mean daily and monthly air temperature was modelled back to 1781 using daily data from Churáňov (Bohemian Forest) and monthly data from Hohenpeissenberg (Germany) (Kettle H., Kopáček J., and Hejzlar J., 2003).

References

Kettle, H., Kopáček, J., and Hejzlar, J., 2003: Modelling Air Temperature at Čertovo Lake back to 1781. *Silva Gabreta*, **9:** 15-32.

2.4 HSCU

HSCU has collated data for three lakes in the Tatra Mountains: Ladové and Starolesnianske pleso in Velká Studená Valley and for Dlugi Staw in Gasienicowa Valley (Table 1).

Ladové	Site of measurement	Parameter	Data series
Meteorology	Lake (automatic weather station)	Temperatur (15 min all) Humidity Wind speed and direction Irradiation	since 2000
Hydrology	Lake (automatic weather station)	Water level (15 min all) Surface water temperature Thermistor chain	since 2000
Atmospheric deposition	Skalnate pleso	Ion balance (wet-only and bulk)	since 1997
Water chemistry	Lake	SO_4-S, N-forms, Si, P, Al, Fe, Ca, Mg, Na, K, Cl, DOC (autumn values)	since 1980

Starolesnianske pleso	**Site of measurement**	**Parameter**	**Data series**
Meteorology	Use data from Ladové	Temperatur (15 min all) Humidity Wind speed and direction Irradiation	since 2000
Hydrology	Lake	Surface water temperature (15 min)	since 2000
Atmospheric deposition	Skalnate pleso	Ion balance (wet-only and bulk)	since 1997
Water chemistry	Lake	SO_4-S, N-forms, Si, P, Al, Fe, Ca, Mg, Na, K, Cl, DOC (autumn values)	since 1980
Dlugi Staw	**Site of measurement**	**Parameter**	**Data series**
Meteorology	Lake (automatic weather station)	Temperatur (15 min all) Humidity, Irradiation Wind speed and direction	since 2000
Hydrology	Lake (automatic weather station)	Water level (15 min all) Surface water temperature Thermistor chain	since 2000
Atmospheric deposition	Skalnate pleso	Ion balance (wet-only and bulk)	since 1997
Water chemistry	Lake	SO_4-S, N-forms, Si, P, Al, Fe, Ca, Mg, Na, K, Cl, DOC (autumn values)	since 1991

Long-term air temperature data was calculated in nearby Nizne Terianske pleso.

Modelling of lake water and soil chemistry in all studied lakes was performed by MAGIC. The results have been published.

2.5 CNR

CNR has selected 4 high mountain lakes with contrasting catchment characteristics: Lago Paione Superiore, Lago Paione Inferiore, Lago Boden Superiore and Lago Boden Inferiore (Table 1). Chemical monitoring of the lakes has continued following standard protocols for sampling and analyses. 2 to 4 samples per year are collected in the ice-free season. New data collated during Euro-limpacs will be considered together with data from previous projects.
The Meteorological station of Lake Paione started its data registration in 1996.

Lago Paione Superiore and Inferiore	**Site of measurement**	**Parameter**	**Data series**
Meteorology	Lake (automatic weather station) at 2269 m a.s.l.	Temperature (30 min) Precipitation Humidity Radiation Wind speed and direction	since 1996
Hydrology	No measurement	(an hydrological budget has been performed within EU-EMERGE for 2000-01 estimating runoff from precipitation and evaporation)	
Atmospheric deposition	Graniga sampling station (wet-only sampler) at 1113 m a.s.l., about 5 km from the Paione lakes	Major ions, pH, alkalinity, total nitrogen, reactive phosphorus (weekly)	since 1994 (a longer record is available from the station of Domodossola, located at 270 m a.s.l.; data since 1986)
Water chemistry	Lake	Major ions, pH, alkalinity Nutrients (varying sampling frequency; ~ 2-4 samples per year)	since 1984
Lago Boden Superiore and Inferiore	**Site of measurement**	**Parameter**	**Data series**
Meteorology	Toggia at 2200 m a.s.l.	Temperature Precipitation	since 1930
Hydrology	No measurements		
Atmospheric deposition	Toggia sampling station (bulk sampler) at 2160 m a.s.l.	Major ions, pH, alkalinity, total nitrogen, reactive phosphorus (weekly)	1981 - 1995
Water chemistry	Lake	Major ions, pH, alkalinity Nutrients (varying sampling frequency; ~ 2-4 samples per year)	since 1984

2.6 UIBK

UIBK has selected the catchment of Piburger See for the analysis of long-term, seasonal and episodic trends in catchment mass fluxes (Table 1).
Long-term meteorological data are available from two stations in the close vicinity of Piburger See with data series back to 1961. Data on atmospheric deposition are derived from 3 stations, which belong to the Austrian Precipitation Monitoring Network. Samples are collected daily using wet-and-dry-only-samplers (WADOS). Since 1975 water quality of Piburger See, its inflow and outflow has been monitored.
High-frequency runoff data are available since October 2003, while the long-term runoff has been modelled back to 1961 using meteorological data from the nearby stations. On-site weather data are registered with an automatic weather station since October 2003.

Piburger See	Site of measurement	Parameter	Data series
Meteorology	Ötz (47°12´N, 10°54´E, 760 m) (Austrian Hydrographic Service)	Precipitation (daily) Temperature (daily)	since 1.1.1961
	Umhausen (47°08´N, 10°56´E, 1041 m) (ZAMG-Central Institute for Meteorology and Geodynamic)	Precipitation (daily) Temperature (daily) Wind (daily) Humidity (daily) Sunshine (daily) Cloud cover (daily) Snow cover (daily)	since 1.1.1961
	Lake (automatic weather station)	Temperature (15 min) (plus wind, radiation, humidity)	since 10.2003
Hydrology	Lake inflow and outflow	Runoff (15 min)	since 10.2003
Atmospheric deposition	Kufstein (47°40´N, 12°14´E, 680 m) Reutte(47°29´N, 10°41´E, 930 m) Innervillgraten (46°49´N, 12°21´E, 1730 m) (WADOS network Austria)	pH, major ions (wet-only)	since 11.1983 since 11.1983 since 08.1984
	Lake	pH, major ions, TP, DOC, DN (bulk - weekly to monthly)	since 10.2003
Water chemistry	Lake, lake inflow and outflow	pH, alkalinity, major ions, TP (monthly) DOC, Si (monthly)	since 1975 since 1998

ANNEX 1: Site specific activities contributing to the major objectives of WP1, complementary work and the cross-links to other WPs of Euro-limpacs

UIBK has selected Piburger See for the analysis of long-term trends. Long-term mass flux assessment will be based on daily meteorological data from nearby weather stations and monthly chemical data from the lake inflow and outflow and lake vertical profile samples (link to WP6). Collated data on atmospheric deposition are derived from a network of wet-and-dry-only samplers in the Tyrol (daily samples).

In addition, during the hydrological year 2004 (October 2003 - September 2004), the lake tributary (Piburger brook) was sampled at weekly intervals at a recently constructed gauge in order to obtain a comprehensive chemical data set for low and high flows. This study includes automatic high-frequency measurements of hydrological data (calibrated weirs at lake inflow and outflow, recorded at 15-minute intervals), electrical conductivity, water temperature as well as on-site meteorological measurements recorded by a new weather station. Both the new gauging stations and the meteorological station (including comprehensive hard- and software for automatic measurements) have been obtained through external national funding providing added value to Euro-limpacs). During the hydrological year 2004, chemical parameters (major ions and nutrients – P, N, C, Si) were measured at 2 precipitation sites, at the lake inflow and outflow, and at 9 depth-intervals of the lake (sampling interval 2-4 weeks).

NIVA has begun to compile of the long-term data for a calibrated catchment at Kårvatn, Norway for subsequent analysis of episodic, seasonal and long-term trends.

SYKE has selected two lake sites for time series analysis, both also studied in WP4 (Valkea-Kotinen, southern Finland and Hietajärvi, eastern Finland). Valkea-Kotinen is the reference site for the lake manipulation study in WP1 Task 3.3. Both lake catchments have been intensively studied with long-term data on hydrology, soil water and surface water chemistry, soil chemistry, vegetation and deposition available. Meteorological data are available from nearby weather stations. The sites are located in protected areas and the catchments are covered with mainly coniferous forests. The estimation of runoff scenarios for changed climate has been discussed with the hydrological modeling group at SYKE (AO/HYD), using the Watershed model system of SYKE.

In order to get background and input data for both the time-series analysis and the development/application of models for predictions of climate change impacts on element leaching (WP1 Task 3.3 and WP4), data on the carbon (and nitrogen) pools and fluxes have been collated from both catchments. The aim, in the first phase, is to document these results for the Hietajärvi site. The dominant ecosystem pools and mean annual fluxes have been estimated.

HBI-ASCR:
Tatra Mountains – Fifty-year climatic records (temperature and precipitation) from Skalnaté Pleso meteorological station were digitised (link to WP4). This work was done together with Partner 22 (HSCU).
Bohemian Forest – Hydrological and chemical data for Plešné and Čertovo catchment-lake ecosystems were collected in the hydrological year, 2004 (November 2003 - October 2004) (link to WP4). This study includes measurements of hydrological data (calibrated weirs at lake outflows, records in 15-minute intervals) and air, soil, and water temperatures. Air (2 m above ground) and soil (5 and 30 cm depths) temperature is monitored in the low and upper parts of each catchment. Measurements of water temperature (major tributaries, chain of registration thermometers at maximum depth) began in May after ice-off. Chemical parameters (major ions and nutrients – P, N, C, Si) were measured at 3 sites for precipitation (1 open area and 2 throughfall areas), all tributaries, output, and 5 depths along the vertical profile of each lake (sampling interval 2-4 weeks).

- Both sites are N saturated, with elevated N leaching since ~1960s. High levels of nitrate were exported from both catchments in 2004 relative to previous years. The reasons for this elevated flux of nitrate (probably climatic – unusually dry summer) have been analysed (links to WP-4).
- Laboratory and field experiments to examine temperature effects on litter decomposition in the Bohemian Forest catchments started in December and are planned to continue for next 3 years (in co-operation with a national project). Data will be used for modelling temperature effects on element export from terrestrial sources.
- Chironomids, diatoms, and pollen analyses of the Plešné Lake core continue and analyses of Cladocera remains has been completed (links to WP4; cross-cutting theme - Palaeolimnology).

Data evaluation:

- Historical trends (1985-2003) in Si concentrations in the Bohemian Forest lakes were evaluated with respect to climatic variability and chemical trends. A manuscript was submitted to Hydrology and Earth System Sciences (Veselý,J. et al.: Silica concentrations are increasing in freshwaters recovering from acidification) (link to WP-4).
- A study on the possible climatic factors responsible for changes in chemical (P and Ca concentrations) and biological (pollen, diatom, Cladocera, and chironomids) composition of a sediment core from Plešné Lake proceeds as planned. A manuscript (Veselý et al.: Late-Glacial/Holocene succession of the cladoceran fauna of the Plešné Lake (Bohemian Forest)) is in preparation. The data suggest a pronounced climate-driven change in cladoceran fauna over the period of ~14,000 years.
- Mass budget studies and laboratory experiments showed that solar radiation had an important impact of on changes in speciation of organically bound metals (Al and Fe). Photochemical liberation of allochthonous organically bound Al and Fe and in-lake hydroxide precipitation are important sources of these metals to lake sediments. The process is described in a manuscript (Kopáček, et al.: Photochemical production of ionic and particulate aluminum and iron in lakes) submitted to *Environmental Science and Technology* (link to WP-4).

HSCU has selected Skalnaté Pleso, Ladové pleso and Dlugi Staw for the analysis of long-term trends. A database containing meteorological data (precipitation, air temperature and cloud cover) at Skalnaté Pleso from 1961 to 2003 has been established (the work was done together with HBI-ASCR, link to WP4 - MAGIC modelling). Data are provided by the Geophysical Institute of the Slovak Academy of Sciences.

At Skalnaté Pleso, sampling and analyses of atmospheric deposition (wet-only and bulk) began in 1997 under EU-MOLAR and EU-EMERGE. Facilities at the Geophysical Institute of the Slovak Academy of Sciences can be used (e.g. the permanent presence of Institute observers, who have been trained to collect samples and are paid for this extra work by project funds.) Precipitation is collected weekly, accumulated biweekly (wet only) and monthly (bulk). Chemical analysis is performed at the Hydrobiological Station Velky Palenec, Blatna, (analyses of ionic composition) and at the laboratory of the Hydrobiological Institute of Academy of Sciences, Ceske Budejovice, (partner No. 21, HBI-ASCR) (nutrients and organic carbon). Data will be used for the work at Ladove pleso, Dlugi Staw, Starolesnianske pleso, Vysne Wahlenebergovo pleso, Velke Hincovo pleso, Popradske pleso, Morskie Oko, Czarny Staw Polski and Zielony Staw Gasienicowy (WP1, WP4 and WP5).

At Ladové pleso (Slovakia) and Dlugi Staw (Poland), the automatic weather stations were renewed in May 2004. Meteorological data as well as data on lake water level and tempature (thermistor chains) are available from 2000. Data at Skalnate pleso are provided by the Geophysical Institute of the Slovak Academy of Sciences (air temperature, relative humidity, global radiation, wind speed and direction, soil temperature). Data have been compiled in a database.

HSCU participated in the determination and palaeolimnological analyses of chironomid capsules in a long sediment core from Plesne lake, Bohemian Forest (linked to the work of HBI-ASCR).

Dissemination and use of the results:
A database containing precipitation and chemistry data has been provided for end users (Tatra National park authorities in Slovakia and Poland). Meteorological and hydrological data from AWS are accessible on a web site for the general public.

Two manuscripts are in preparartion: (i) Hydrological regime of the high mountain lakes in the Tatra Mountains (Krecek, J., Stuchlík, E., Turek, J., Mikšovský M.) and (ii) Chemistry of precipitation in the SE slope of the High Tatra Mountains (Strunecký, O., Lopatová, E., Kopáček, J., Stuchlík, E.) . Manuscripts are being prepared for the Special Issue of *Biologia* (Bratislava).

CNR has selected Lago Paione Superiore, Lago Paione Inferiore, Lago Boden Superiore and Lago Boden Inferiore for the analysis of long-term trends. CNR has continued chemical monitoring of the selected alpine lakes following standard protocols for sampling and analyses. Two to four samples per year are collected in the ice-free season. New data collated during the project will be considered together with data from previous projects. Work on the evaluation of historical trends (1980-2004) of the main chemical variables is in progress.

The automatic meteorological station at Lake Paione started logging data in 1996 (data are stored at 30 minutes intervals). Precipitation, temperature, humidity, wind velocity and direction, global solar radiation data are recorded along with water temperature which was monitored until 2001

Data evaluation:
Much of the variability in air temperature at upland sites can usually be explained by temperature series at lowland stations located within a range of 400 km. In particular, long-term air temperature data at Domodossola (since 1870) and at meteorological stations near the Paione lakes (since the beginning of the 1900s) are highly correlated with temperature values registered by the AWS at Lake Paione Superiore for 1997-2002 ($R^2 = 0.93$, $p<0.001$). An increasing trend is evident since 1970 and the 1990s were the warmest decade of the entire record. The highest values of the period were recorded in 1992 and 2003. In the lake area, the mean air temperature increased between 1.7 °C and 0.6 °C during the last 30 years, being higher at low altitude sites (Rogora et al., 2004). No trend was found in precipitation recorded in the lake area, even though a more detailed analysis of the data revealed an increasing occurrence of stormy precipitation events in the last decades (Lami et al., 2002). A decrease in snow depth and duration has been detected during the last 15 years, being most pronounced in the period 1985-2000 (Rogora et al., 2003).

The effect of air temperature, precipitation and snow cover on lake water chemistry has been evaluated for the alpine lakes Paione Inferiore and Superiore (LPI and LPS) and Boden Inferiore and Superiore (LBI and LBS). In general, low solute concentrations correspond to the dilution effect of wet years, while peak concentrations of weathering related ions are detected after dry periods.

Paione lakes are mainly sensitive to acidic input from the atmosphere due to their low solute content and limited buffering capacity, whereas Boden Lakes are strongly affected by weathering processes in the catchment area. The observed increase in sulphate concentrations of Lake Boden (Fig. 1) can be related to higher summer temperatures, a shorter snow-cover period and more intense weathering with the dissolution and transport of calcium and magnesium sulphate from the catchment to the lakes. This increasing SO_4 flux from geological sources may balance the decreasing input of sulphate from the atmosphere (Rogora et al., 2003).

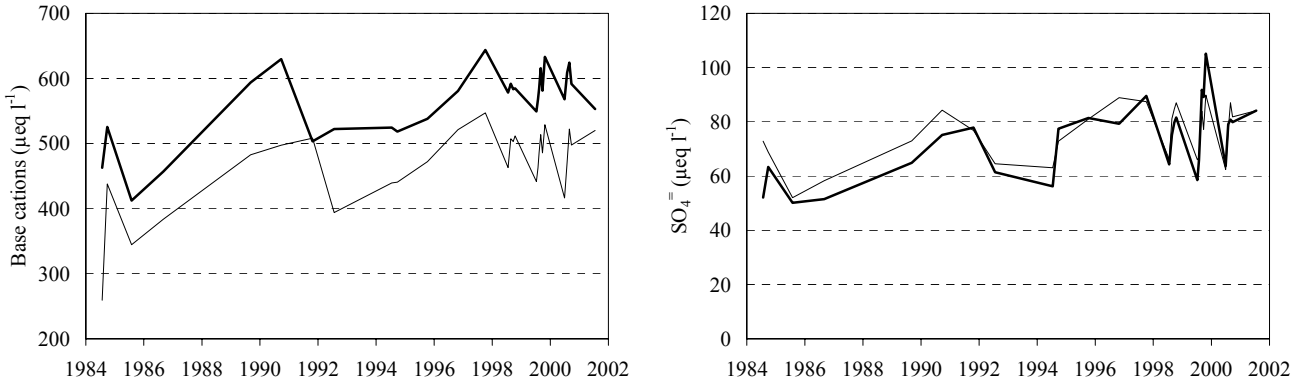

Fig. 1. Trends of base cations and sulfate in Lake Boden Superiore (—) and Inferiore (▬), 1984-2003.

ANNEX 1 References

Kopáček, J., Š. Klementová, and S. A. Norton - Photochemical production of ionic and particulate aluminum and iron in lakes", submitted to Environ. Sci.Technol.

Lami A., Maugeri M., Mosello R. & Puricelli R. (2002) - *La serie ultrasecolare di misure dell'Osservatorio Meteorologico "A. Rosmini" di Domodossola. II. La temperatura dell'aria*. Oscellana, *12*, 13-27.

Rogora, M., R. Mosello & S. Arisci. 2003. The effect of climate warming on the hydrochemistry of alpine lakes. *Water Air Soil Poll*., 148: 347-361.

Rogora, M., S. Arisci & R. Mosello. 2004. Recent trends of temperature and precipitation in alpine and subalpine areas in North Western Italy. *Geografia Fisica e Dinamica Quaternaria* (in press)

Veselý, J., V. Majer, J. Kopáček, J. Šafanda, and S. A. Norton.: Silica concentrations are increasing in freshwaters recovering from acidification. Submitted to Hydrology and Earth System Sciences.