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Hydrology and Earth System Sciences

Role of climate change in recovery of acidified surface waters

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Abstract. Surface waters in Europe and North America have begun to recover in response to decreases in emissions of acidifying pollutants to the atmosphere. Variations in climate influence chemical and biological recovery. Part of the EU project Eurolimpacs (Integrated project to evaluate the impacts of global change on European freshwater ecosystems) focuses on the interactive effects of acid deposition and climate on freshwater ecosystems. This special issue of Hydrology and Earth System Sciences is devoted to this topic, and consists of studies conducted in 8 countries on aspects regarding episodes, nitrate, dissolved organic carbon, recovery and biological effects.

1 Introduction

Acid deposition and acidification of surface waters has been a major environmental problem in many regions of Europe and eastern North America. International efforts to reduce the emissions of acidifying sulphur (S) and nitrogen (N) compounds have resulted in major reductions in acid deposition since the mid-1980s. In Europe much of this has been achieved through the United Nations Economic Commission for Europe's (UN-ECE) Convention on Long-range Transboundary Air Pollution (CLRTAP) (UNECE, 2002). In North America emission reductions have been regulated nationally through such legislation as the 1991 Canada – United States Air Quality Agreement and the US Clean Air Act.

As a result emissions of S and N in Europe have declined by about 65% and 25%, respectively, in the period 1990–2004 (Tarrason et al., 2006). Acidified surface waters have begun to recover, with decreasing concentrations of sulphate (SO_4) and increasing acid neutralising capacity (ANC) and pH (Stoddard et al., 1999; Evans et al., 2001; Jeffries et al., 2003). Biological recovery has also been reported (Hesthagen et al., 2001; Holt and Yan, 2003).

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Further chemical and biological recovery is expected in the future as emission of S and N continue to decline and surface waters respond to these reductions. Chemical recovery in response to future changes in emissions has been modelled for several acid-sensitive regions in Europe as part of the EU projects RECOVER:2010 and EMERGE (Wright et al., 2005).

It has long been apparent, however, that climatic variations affect acidification and recovery of surface waters. The effects can be episodic, such as acid pulses caused by seasalt events (high winds) (Hindar et al., 1995) or by drought-induced changes in catchment redox processes (Dillon et al., 2003a, b), seasonal, such as the typical pattern of low concentrations of NO_3 in summer and high concentrations in winter (Stoddard, 1994), and long-term, such as the increase in dissolved organic carbon concentrations in many surface waters during the 1990s (Evans et al., 2005).

2 Structure of the special issue

The articles are grouped by topic rather than by country in which the studies were carried out (Table 1). The first 5 articles deal with climate-induced short-term events (acid episodes) that affect the recovery process. Studies on episodes come from the UK (Evans et al., 2008), Norway (Wright, 2008), Sweden (Laudon, 2008), Italy (Rogora et al., 2008), and Canada (Aherne, 2008). The next 3 articles address variations in nitrate (NO_3) concentrations, two from Norway (de Wit et al., 2008; Hole et al., 2008) and one from Poland (Rzychoń and Worsztynowicz, 2008). These are followed by 2 articles dealing with dissolved organic carbon (DOC) concentrations, one in Sweden (Laudon and Buffam, 2008), and one in Finland (Futter et al., 2008). Three articles deal with recovery from acidification, two in Finland (Posch et al., 2008; Vuorenmaa and Forsius, 2008), and one in the Czech Republic (Hardekopf et al., 2008). Finally there are two articles dealing with biological aspects, both from Norway (Kroglund et al., 2008; Lydersen et al., 2008).

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Table 1. Articles (denoted by first author) included in this special issue placed into a matrix of topics and countries.

Topics	Norway	Sweden	Finland	Countries UK	Czech Republic	Poland	Italy	Canada
Episodes	Wright	Laudon		Evans			Rogora	Ahearn
NO_3	Hole de Wit					Rzychoń		
DOC		Laudon	Futter					
Recovery			Posch Vuorenmaa		Hardekopf			
biology	Kroglund Lydersen							

The majority of these articles report work conducted as part of the EU project Eurolimpacs (Integrated project to evaluate the impacts of global change on European freshwater ecosystems) and associated national research. One of the work packages in Eurolimpacs deals specifically with the combined impact of acid deposition and climate change on freshwater ecosystems. The work reported here comes from the first phases of Eurolimpacs. Eurolimpacs will continue through January 2009.

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