Introduction

The subalpine and alpine areas in North-Western Italy and Southern Switzerland receive high deposition of atmospheric pollutants transported from emission sources in the Po Valley, one of the most urbanised and industrialised areas of Europe. Long-term studies, covering a 30-year period, on atmospheric deposition and its effects on surface water bodies have been performed in this area in the framework of the ICP WATERS (BOX 1) and of national projects. Studies on both deposition and surface water chemistry have been performed since the beginning (early 1980’s) through a cooperation between Swiss and Italian research institutions.

Methods

Samples are analysed for pH, conductivity, alkalinity, major anions and cations. Details on sampling and analytical procedures can be found in Rogora et al. 2012 and Steingruber 2015. The quality of the data was assured by regular participation to national and international intercomparisons.

Weekly sampling of rainwater with wet-only samplers started in 1988. Monthly and yearly mean concentrations in precipitation were calculated by weighting weekly concentrations with the sampled precipitation volume, while monthly and yearly wet deposition were calculated by multiplying yearly and monthly mean concentrations with the precipitation volume measured at the site itself or at a meteorological sampling station close to the sampling site.

Long-term trends and spatial patterns

- The analysis of the data at a spatial level (Fig. 3) highlighted a gradient in the deposition of acidity, sulphate and nitrogen compounds, with decreasing values with altitude and in the northern part of the area.
- Deposition data show a high interannual variability, due to the highly variable precipitation amount affecting this area (from 1200-1300 mm in dry years up to 3000 mm (BOX2)).
- The analysis of long-term trends revealed a substantial reduction in sulphate deposition, which almost halved since the 80’s (BOX2).
- Deposition of oxidised and reduced nitrogen has not changed to the same extent, showing a slight tendency to decrease only in the most recent period. Nitrogen deposition is still high, also at the alpine sites (32 and 27 meq m⁻² y⁻¹ at Devero and 42 and 48 meq m⁻² y⁻¹ at Robiei for ammonium and nitrate, respectively (BOX3)).
- The NH₄/NO₃ ratio in atmospheric deposition has increased in time at most of the sites, from about 1.2 in the 1984-2002 period up to 1.4-1.5 in recent years, indicating an increasing importance of NH₄ deposition (BOX3).
- The relative contribution of acidifying compounds to potential acidity at the sites of Pallanza (Italy) and Locarno (Switzerland) showed a decreasing contribution of SO₄, while NH₄ and NH₃ became more and more important. Furthermore, ammonium has become the dominant form of N in deposition at most of the sites.

Major findings

- The clearest decrease in deposition through time can be observed for potential acidity, mainly determined by the significant decrease in deposition of sulphate. A decrease in deposition of nitrate and ammonium is more difficult to observe.
- Deposition of base cations tend to be constant over time but can increase significantly in correspondence of alkaline rain events. These events significantly contribute to the total deposition of calcium, magnesium and alkalinity but also of other chemical compounds such as nitrogen and phosphorus.
- The pattern of deposition still show a north-south gradient in recent year, with higher values in the southern part, even if much less evident with respect to the previous period.
- At present, nitrate and ammonium are the dominant acidifying agent at these sites. Further reductions of N emissions and deposition, especially reduced N, are needed.

References