Abstract. Substantial fluctuations in precipitation and runoff have occurred over the Nile Basin in recent decades. Ten-year mean flows of the Blue Nile (Khartoum gauge) during the 20th century have ranged from 42.2 to 56.7 km$^3$ and for the White Nile (Malakal gauge) from 25.5 to 36.9 km$^3$. These fluctuations have been responsible for changes in decade-mean Main Nile discharge of up to ±20% which have had important consequences for water resource management in both Egypt and Sudan.

This paper provides a review of the Nile Basin hydrology incorporating, for the first time, analyses of the relationships between precipitation and runoff fluctuations in the instrumental period for each of the eight major sub-basins within the Nile Basin. These sub-basins possess very different physical, climatic and hydrological characteristics. Over 90% of the Main Nile discharge originates from only four of the sub-basins; Lake Victoria, Blue Nile, Atbara, and the Sobat. Interbasin correlations of 40 y (1945–84) precipitation and runoff annual time series identify two broadly homogeneous regions; the Ethiopian highlands (Blue Nile and Atbara) and the Lake Victoria and Equatorial Lakes (White Nile). These regions possess contrasting precipitation regimes whose interannual variations are uncorrelated in time and which are therefore associated with different atmospheric circulation anomalies. The observed relationships between catchment precipitation and runoff, however, are not straightforward and the sensitivity of runoff to precipitation fluctuations varies from basin to basin. Some of the water resource management implications of these fluctuations for Egypt are discussed. With water demand in Egypt alone set to increase 17% by the year 2000, it is critical that the role of future climate change in Nile water management is thoroughly assessed based on a correct modelling of the diverse hydrological characteristics of the various Nile sub-basins.

1. Introduction

Over the last one hundred years there have been considerable variations in the flow of the river Nile. After completion of the High Aswan Dam in 1963 a series of high flow years enabled the rapid filling of the High Aswan Dam reservoir, which by 1978 had reached near maximum capacity. However, from the late 1970s and into the 1980s a prolonged period of low annual flows led to a critical fall in reservoir levels. In July 1988 the level of the reservoir was at its lowest since dam construction and Egypt was forced to seriously reconsider future policies for managing dam releases (Abu-Zeid and Abdel-Dayem, 1992). The situation was only alleviated by the timely high annual flood of 1988, the largest in 13 y.
Many studies have examined the historical flows of the River Nile. These have concentrated on either the riverflow time series at Aswan, where the Nile enters Egypt and the earliest modern gauge was established (e.g., Hurst et al., 1965; Riehl et al., 1979), or the ancient time series at Roda dating back to 641 AD (e.g., Hassan, 1981). Apart from a number of detailed studies of Lake Victoria and the Equatorial Lakes by the World Meteorological Organisation (WMO) and the Institute of Hydrology (IH) (Hydromet, 1983; IH, 1984) few attempts, however, have been made to quantify the relationship between historical fluctuations in the Main Nile flows with historical fluctuations in precipitation over the Nile Basin. Such an analysis is needed to fully understand past fluctuations in Main Nile discharge and is a key stage in the assessment of sensitivity of runoff in the Nile Basin to future climate change.

This paper presents an overview of the hydrology of the Nile Basin and its eight component sub-basins (NSB). Recent fluctuations in precipitation and runoff over the NSB are analysed, providing an insight into the spatial and temporal relationships between precipitation and runoff over the Nile Basin. This analysis utilises historical time series of monthly precipitation for over one hundred raingauges and discharge data from nine gauging locations within the Basin. The impacts of these precipitation fluctuations on Main Nile flows and their implications for water resource management and for the assessment of future climate change impacts on Nile discharge are briefly discussed.

2. The Nile Basin

The Nile Basin extends from 4° South to 31° North, includes nine different countries, and has an area of roughly 2.9 million km² (Figure 1). Since the earliest Egyptian civilisation the Nile has possessed both a mystical and a practical significance to the peoples of the downstream states. The annual flood which rose out of the desert provided ideal conditions for the development of settled agriculture and led to the study of the Nile from very early times. Records of the annual flood peak exist back to 3000 BP at a number of ancient measuring sites up and down the Nile within Egypt. These sites were known as Nilometers and the most famous is the Roda gauge on Roda Island, Cairo. The records at this site date back to 641 AD and have been studied in a number of papers. The most detailed of these is by Popper (1951) and in this, and other papers (e.g., Hurst et al., 1965; Currie, 1987; Balek, 1990; and Evans, 1990), these long Nile flow records have been analysed for trends, cycles, and anomalous periods.

This present study, however, is limited to an analysis of the more recent precipitation and riverflow records from the last 100 y. Reliable monthly riverflow data for most of the important Nile tributaries are available back to the beginning of the century. An extensive network of gauges was established by the British and Egyptian authorities to monitor all the major tributaries in the Nile Basin. This work was undertaken to expand the knowledge of Nile Basin hydrology for future river basin