Preface

Traditionally, the terrestrial part of the hydrological cycle is studied by hydrologists while the atmospheric part is left to atmospheric scientists. Consequently, and unfortunately, these two branches of Earth Science have shown limited interaction, apart perhaps from the study of evaporation and precipitation generation. The last two decades have shown an increased interest in climate change and its impacts, not only by the atmospheric science community, but also by hydrologists. The first studies on hydrology and climate that were performed by hydrologists focused on the impact of climate change and variability on the water balance and river discharge. Recently, atmospheric scientists have turned more and more to hydrology to come up with better land–atmosphere parameterizations in order to improve climate models and weather prediction. These developments have led to an almost separate hydrological discipline, called "climate hydrology", in which hydrological systems are viewed as part of the climate system, being both influenced by climate change and variability, as well as constraining the climate system through positive and negative feedbacks. The study of the hydrological cycle in the context of the climate system has developed sufficiently to warrant a self-contained book on the subject.

The purpose of this book is to provide an in depth overview of the role of the hydrological cycle within the climate system, including climate change impacts on hydrological stores and fluxes, as well as controls of terrestrial hydrology on regional and global climatology. The book is intended to serve as material for graduate and postgraduate courses in climate hydrology and hydroclimatology. Furthermore, its contents will be of interest to scientists and engineers/practitioners interested in the water cycle, weather prediction, and climate change.

The book started out as lecture notes provided by the lecturers of an international summer course named "Climate and the Hydrological Cycle" which was held at Utrecht University, 4–15 July 2005, with 55 participants from various parts of the world. This was the first summer course organized by the Boussinesq Centre for Hydrology, which is the Dutch centre that aims to promote fundamental hydrological research. Its members are the university-based hydrology groups in The Netherlands, and we happily refer to the website (*www.BoussinesqCenter.nl*) for an overview of their activities.

The lecture notes were reviewed by the editors, resulting in 15 self-contained chapters by specialists in the field of hydrology and climate science. The logic of the chapters' contents follows that of the original course and is as follows:

We start out with an introductory chapter providing an overview of the role of the hydrological cycle in the climate system. Next, we focus on the drivers of the hydrological cycle: evaporation and precipitation. Evaporation theory and observations are treated in Chapter 2, while Chapter 3 treats evaporation as part of the dynamics of the planetary boundary layer. Next, Chapter 4 provides a description of precipitation physics and of the various ways of observing precipitation, including remote sensing. In the following four chapters we focus on hydrological processes at the land surface (Chapter 5) and how these processes are generally conceptualized in the land surface component of weather prediction and climate models (Chapter 6). As climate change is expected to have the greatest impact at the higher latitudes, Chapter 7 deals with hydrological processes of sub-arctic regions and how climate change impacts these processes. Chapter 8 is another "cold chapter", describing the dynamics of glaciers and ice sheets and how these relate to sea level change. Because of their long turnover times, we sometimes forget that glaciers and ice sheets are also part of the terrestrial hydrological cycle. We are proud that we charmed a leading glaciologist to fill this gap.

As the first part of the book (chapters 2 to 8) deals with the various components of the hydrological cycle, in the second part (chapters 9 to 14) the hydrological cycle is treated in its various modes of interaction with the climate system. We begin with two important feedbacks that are currently the subject of much research. First, the role of soil moisture–precipitation feedbacks is treated in Chapter 9. These feedbacks are important at the sub-daily to seasonal time scale, i.e. the scale of weather prediction. In Chapter 10 we treat the exchange of carbon between land and atmosphere, which is intimately linked to hydrology. Understanding this feedback, which operates at larger time scales, is essential to predicting climate change. To understand how climate impacts hydrology, much can be learned from the past, while relics from the past may teach us a lot about past climate variability. This is the topic of Chapter 11, where an overview is given of methods to reconstruct the components of the terrestrial water balance in the past. The appendix to this chapter provides a review about the use of palaeo-climatological model experiments in understanding the sudden climate change at the end of the African humid period 6000 years ago. This case study exemplifies the importance of vegetation dynamics and hydrology in climate change. This chapter is followed with a review on groundwater palaeohydrology (Chapter 12), showing, through various types of tracers, that groundwater bodies are valuable repositories of past climate change information. The treatment of interaction between the hydrological cycle and the climate system culminates in two chapters about climate change. Chapter 13 deals with the much debated question as to whether climate change is already causing the hydrological cycle to speed up. Here the various, often contradictory, observational evidence is reviewed. Chapter 14 describes methods of determining the hydrological impact of climate change, including various ways of downscaling and bias-correcting climate scenarios. Much of the current research into the global water and energy cycle depends heavily on remotely sensing. Therefore, we complete the book with an overview of various remote sensing techniques and satellite missions designed to monitor components of the hydrological cycle (except for rainfall by radar, which is treated in Chapter 2).

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Marc F. P. Bierkens
Peter A. Troch
A. J. (Han) Dolman
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