Impacts of Global Warming on Mountain Runoff: Key Messages From the IPCC Report

Global warming is affecting snow and ice – i.e. the mountain cryosphere – altering seasonal runoff patterns. Hydrological cycles will gradually shift from being dominated by snow and ice to being determined by rain. These are two of the key messages from the 2013 IPCC Report relating to mountain waters [1, 2].

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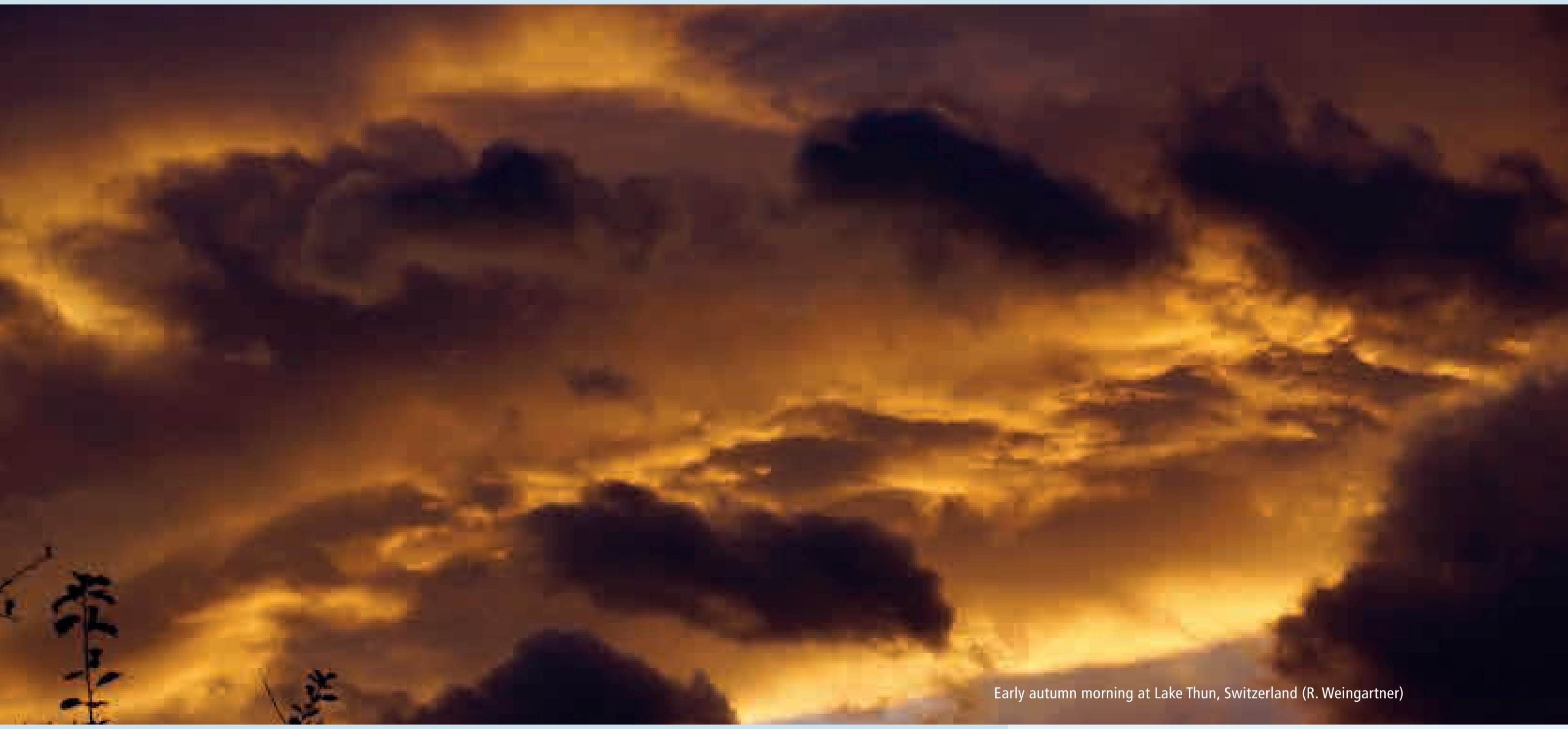


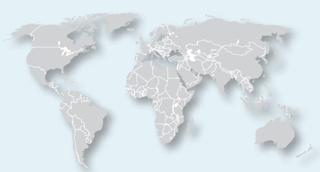
Early autumn morning at Lake Thun, Switzerland (R. Weingartner)

The main climatic drivers of runoff are precipitation and temperature, in addition to (net) radiation and – in mountainous environments – the cryosphere. Observed increases in the moisture content of Earth's atmosphere are likely to cause changes in precipitation patterns, leading to intensification of heavy rainfall over land regions. Increased precipitation is expected to occur around mountain ranges in the northern hemisphere at higher latitudes, in East Africa and New Zealand, whereas the Andes and mountains in West Asia and West Africa are expected to become drier. The largest precipitation changes over northern Eurasia and North America are projected to occur during the winter. Precipitation and precipitation extremes, however, are subject to large modelling uncertainties indicated by the large discrepancies between simulation models.

Increasing air temperatures are very likely. The remaining uncertainty is mostly due to divergent emissions scenarios. As a consequence of the diminishing significance of the cryosphere, net radiation is going to change in mountain areas – specifically, more energy will be available for latent (evapotranspiration) and sensible heat. Changes in temperature and precipitation are reflected in the cryosphere, which is composed of snow, glaciers and permafrost. The critical point is when air temperatures are close to freezing; it is here that changes in air temperatures have the greatest effect on the timing of snow accumulation and snowmelt as well as on the number of snowfall events. Overall, these changes result in a shorter period of snow cover – for example, a significant reduction in snow cover extent has already been

"Changes in the global water cycle in response to the warming over the twenty-first century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase."

IPCC, 2013 [1]



Blüemlisalp (3 660 m) seen from Kandersteg, Switzerland (R. Weingartner)

observed in the northern hemisphere for the period from 1967 to 2012 (Figure 2.10). Further, simulations indicate that March-to-April snow cover will likely decrease by 10–30 percent, on average, by the end of this century.

Runoff integrates climate-induced changes within a catchment. In terms of mountain rivers, a seasonal redistribution of runoff is expected, i.e. river regimes will change; however, total annual runoff volumes may or may not change, depending on annual precipitation levels. Greater variability of river flows is likely to be expected, as the damping effect of snow and ice storage will gradually diminish. Droughts and floods are expected to occur more frequently for the same reason.

In many mountain regions, the dry summer season can be bridged by using the abundant water from snow and ice melt. The challenge is to maintain this seasonal structure. This will likely require building new multi-purpose storage infrastructure and transforming existing infrastructure from single-purpose (e.g. hydropower generation) to multi-purpose (e.g. hydropower generation and drinking water supply).

"Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments (high confidence)."

IPCC, 2014 [2]

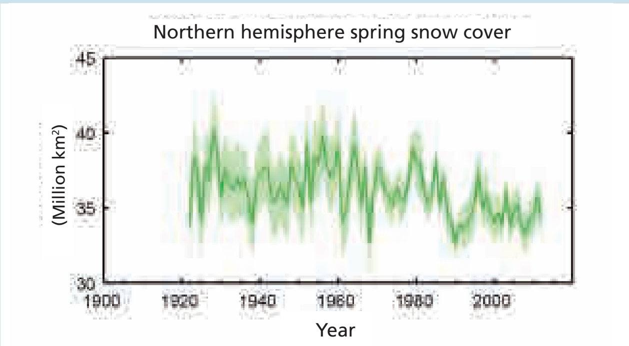


Figure 2.10. Extent of average snow cover in spring (March to April) in the northern hemisphere. Green line: annual values; green shading: uncertainties. Source: [1]