



Quantifying the Water Tower of the Third Pole: State of the Art and Research Challenges

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Mountains are the water towers of the world, particularly in Asia, where rivers all are fed from the Tibetan plateau and adjacent mountain ranges. In this area, referred to as the Third Pole, snow and glacial melt are important hydrologic processes, such that climate change is expected to seriously affect melt characteristics and related runoff. The Third Pole provides water resources to nearly two billion people in Asia. However, uncertainty about key hydrological processes at high altitudes generally precludes the assessment of the potential impact of climate change on runoff. First we review recent geodetic and direct mass balances measurement of glaciers and we compare observations to a regional scale analysis of corrected mass balance anomalies based on gravitation measurements derived from the GRACE satellite. We then assess the state of the art in modeling the impacts of climate change on the water resources of the Third Pole at different scales. Our analysis first shows the regional differentiation in the importance of snow and glacial melt water to total runoff and how this may potentially change in the future for five major Asian river basins. For this analysis we use a lumped degree day factor hydrological model that we force using remote sensing data on snow cover and precipitation and which is calibrated using observed discharge data. We then focus on a number of smaller benchmark glaciated catchments that cover all climatic zone of the Third Pole. Using a model that explicitly simulates glacier movement in combination with major hydrological processes at a high spatial resolution, we show the diversified response of glaciated catchment to climate change and test whether this response is related to the west-east gradient in climate. We conclude by formulating the future research challenges and major uncertainties related to hydrological modeling on the Third Pole.