Precipitation and snow resources in the Hindu-Kush Karakoram Himalaya mountains: current picture and expected changes

Silvia Terzago[1], Elisa Palazzi[1], Jost von Hardenberg[1], Antonello Provenzale[1]

[1]Institute of Atmospheric Sciences and Climate ISAC-CNR, Torino, Italy, s.terzago@isac.cnr.it

The Hindu-Kush Karakoram Himalaya and the Tibetan Plateau extend for about 5 million Km^2 and they are the largest mountain range in the world, including the 14 world's highest peaks above 8,000 m. This mountain range shapes the atmospheric circulation and the climate of South-Eastern Asia. In fact the HKKH mountains act as an orographic barrier that forces the impinging humid air masses to rise and cool, producing precipitation in the form of rain or snow.

Two main dynamical mechanisms bring humidity to the HKKH region: the summer Indian monsoon, which transports warm and moist air from the Indian Ocean northward, producing heavy precipitation during summer months, and the Western Weather Patterns (WWPs), which are weather disturbances coming from the Mediterranean and Caspian Sea and propagating eastward, mainly during winter months (Singh 1995). While the summer Indian monsoon mainly affects the southeastern slope of the Himalaya, the WWPs discharge precipitation mainly over the Hindu-Kush Karakoram mountains, feeding the glaciers and the snow reservoirs. Both summer monsoon and WWPs deeply influence human activities ,,with the former supplying water for agriculture in the dry season in the form of intense and widespread precipitation, and the latter accumulating snow resources that assure continuous river flow also in the driest months.

Changes in the spatial patterns and timing of precipitation, both liquid and solid, in HKKH would impact heavily on water resources availability in lowlands. This study evaluates the properties of precipitation in the Hindu-Kush Karakoram Himalaya region, in term of spatial pattern and temporal variability, using currently available data sets, i.e. satellite rainfall estimates (Tropical Rainfall Measuring Mission), reanalyses (ERA-Interim), gridded in situ rain gauge data (Asian Precipitation Highly Resolved Observational Data Integration Towards Evaluation of Water Resources, Climate Research Unit, and Global Precipitation Climatology Centre), and a merged satellite and rain gauge climatology (Global Precipitation Climatology Project). The results are discussed in relation to those obtained from the Global Climate Models (GCM) simulations participating in the Climate Model Intercomparison Project Phase 5 (CMIP5; Taylor et al., 2012). We highlight the strengths and weaknesses of all datasets, the skill of the GCMs and the related uncertainties.

A similar analysis has been carried out on the snowpack dynamics, still poorly known due to the difficulties in performing regular meteorological observations in high elevation areas (Qian et al., 2003). We studied the representation of snowpack, in terms of snow depth and snow water equivalent, in the HKKH region, given by a set of Global Climate Models, comparing with the main observational datasets (the National Snow and Ice Data Center Global Monthly EASE-Grid Snow Water Equivalent Climatology, the AMSR-E/Aqua Monthly L3 Global Snow Water Equivalent, the Canadian Meteorological Centre Daily Snow Depth Analysis Data) and reanalyses (ERA-Interim/Land, NCEP-CFSR, 20th Century Reanalysis V2).

We analysed precipitation trends in winter (December-April) and summer (June-September) over the "historical" period (1850-2005) covered by GCM simulations and, particularly for the winter seasons, we related the precipitation changes to the snow depth trends. For both variables we investigated the future projections up to the end of the XXI century under two climate change scenarios, RCP4.5 and RCP8.5, in order to highlight the changes that will likely affect the water cycle and water availability in the HKKH region.

References

Qian, Y.F., Zheng, Y.Q., Zhang, Y. and Miao, M.Q., 2003, Responses of China's summer monsoon climate to snow anomaly over the Tibetan Plateau, International Journal of Climatology, 23, 593-613.

Singh, P., Ramasastri, K. and Kumar, N., 1995, Topographical influence on precipitation distribution in different ranges of Western Himalayas, Nord. Hydrol., 26 (4-5), 259-284.

Taylor, K.E., Stouer, R.J. and Meehl, G.A., 2012, An Overview of CMIP5 and the Experiment Design, Bulletin American Meteorological Society, 93, 485-498.