



# **Climatic and extreme weather variations over Mountainous Jammu and Kashmir, India: Physical explanations based on observations and modelling**

Sumira N. Zaz<sup>1</sup>, Romshoo Shakil Ahmad<sup>1</sup>, Ramkumar Thokuluwa Krishnamoorthy<sup>2\*</sup>, and  
Yesu Babu Viswanadhapalli<sup>2</sup>

1. Department of Earth Sciences, University of Kashmir, Hazratbal, Srinagar,  
Jammu and Kashmir-190006, India

2. National Atmospheric Research Laboratory, Dept. of Space, Govt. of India, Gadanki, Andhra  
Pradesh 517112, India

**Email:** zaz.sumira@gmail.com, shakilrom@kashmiruniversity.ac.in, tkram@narl.gov.in,  
yesubabu@narl.gov.in;

**\*Corresponding author** (tkram@narl.gov.in)

## **Abstract**

The Himalaya is very sensitive to climatic variations because of its fragile environmental and climatic settings. There are clear and strong indicators of climate change reported for the Himalaya, particularly the Jammu and Kashmir region in the western Himalayas. In this study, the detailed characteristics of long and short term as well as localized variations of temperature and precipitation are analysed for six meteorological stations (Gulmarg, Pahalgam, Kokarnag, Quazigund, Kupwara and Srinagar) over Jammu and Kashmir, India for a period of 37 years during 1980-2016 by making use of observed stations data, WRF model downscaled monthly-averaged surface temperature and precipitation and ERA-interim (ERA-I) reanalysis data. The annual and seasonal temperature and precipitation changes were analysed by carrying out the Student's t-test, Mann-Kendall, Spearman Rho and Cumulative deviation statistical tests. The results show an increase of 0.8°C in average annual temperature over thirty years during 1980-2016 with higher increase in maximum temperature (0.97°C) compared to minimum temperature (0.76°C). Analyses of annual mean temperature at all the stations reveal higher rise at high-altitude stations of Pahalgam (1.13°C) and Gulmarg (1.04°C) at the confidence level of S=99%. Precipitation patterns in the valley show slight decrease in the annual precipitation at Gulmarg and Pahalgam stations at the confidence level of S=90%. Seasonal analyses show increase in the winter and spring temperature at all stations at the confidence level of S=95% with prominent decrease in spring precipitation at S=99%. The present study reveals that variation in temperature and precipitation during northern winter (December - March) has close association with the North Atlantic Oscillation (NAO). Further, the observed temperature data (monthly averaged data for 1980-2016) at all the stations shows good correlation of 0.86 with the results of WRF and therefore the model downscaled simulations can be