

Machine learning-based verification of satellite weather alerts for heavy rainfall in Ladakh

Nita H. Shah¹, Jyoti Chahal^{1,*}, Anupam Priamvada² and Bipasha Paul Shukla³

¹Department of Mathematics, Gujarat University, Ahmedabad 380 009, India

²Department of Mathematics, Pandit Deendayal Energy University, Gandhinagar, Raysan, Gujarat 382 007, India

³Environment Sciences Division, Space Applications Centre, Indian Space Research Organisation, Ahmedabad 380 015, India

The present study investigates heavy rainfall patterns and their variability in Ladakh by using K-means clustering with the Apriori algorithm, which uncovers the co-occurrence pattern of heavy rainfall alerts obtained from the ISRO MOSDAC portal. The proposed algorithms reveal that location (lat.: min. = 32.82, max. = 35.71; long.: min. = 77.59, max. = 79.91) and location (lat.: min. = 33.11, max. = 35.76; long.: min. = 75.82, max. = 77.75) exhibit the highest confidence (79.55%) and frequency (48.61%) among all patterns, indicating strong interdependencies. This suggests that the alerts in one location can potentially impact the other, offering actionable guidance for disaster preparedness. The present study highlights a significant match between predicted alerts and actual heavy rainfall events, underscoring the utility of machine learning in refining weather alert systems.

Keywords: Apriori algorithm, disaster management, heavy rainfall alerts, K-means clustering.

cloudburst claimed at least 600 lives and caused extensive infrastructure damage within less than two hours, with the most intense rainfall lasting only about half an hour¹⁰⁻¹⁴. In July 2023, a cloudburst in Leh and subsequent heavy rainfall events led to landslides, disrupting critical transportation routes like the Leh–Kargil–Srinagar National Highway at Lamayuru¹⁰.

Despite the severity of extreme weather events, disaster preparedness in Ladakh remains limited due to the absence of automatic weather stations and reliance on satellite-based data. This gap highlights the urgent need for accurate prediction methods to identify high-risk areas for heavy rainfall. The inability to precisely determine the locations of extreme events hampers effective disaster response and mitigation, leaving communities increasingly vulnerable. While previous studies have largely focused on broader climate trends in Ladakh, understanding the spatial relationships of heavy rainfall events is equally crucial. Given the growing impact of global warming, Ladakh has become a key region for research due to its susceptibility to flash floods and landslides^{5,8,15}.

In this context, our research endeavours to unravel