Study of Extreme Weather Events over India using NCMRWF Global Reanalysis

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Introduction:

Using the Global Data Assimilation Forecasting System (GDAFS), the National Centre for Medium Range Weather Forecasting (NCMRWF) has been producing real-time medium-range weather forecasts, known as NGFS, since 1994 alike the Global Forecast System (GFS) model and the NCMRWF Unified Model (NCUM) over the Indian region. In order to improve this system, the 2011 version of the NGFS model and analysis scheme was used to produce a 20-year retrospective analysis known as the NGFS reanalysis for the years 1999 to 2018 (Prasad et al., 2011). In order to help the scientific community, NCMRWF produces NGFS, a high-resolution global atmospheric reanalysis. Notably, Prasad et al. (2017) made a considerable improvement to the NGFS model by raising its horizontal resolution to T574 (about 22 km) with 64 vertical levels. A wide variety of data sources are incorporated into the NGFS model, including conventional global data as well as satellite-based measurements such as atmospheric motion vector winds, radiance, and scatterometer ocean surface winds. Prasad et al. (2014) has elaborated a more thorough understanding of the parameterization techniques used in the NGFS model. Prasad et al. (2017) provide detailed information about the retrospective analysis and its value.

Key findings:

This NCMRWF Global Forecast System (NGFS) retrospective analysis data for 17 years was utilized to acquire insight into the frequency and features of cold wave episodes in Northwest India. There were 21 cold wave occurrences, making a totality of 202 cold nights between 2000 and 2016, five of which were particularly severe (63 cold nights). It's interesting to note that 10 of these incidents happened in La Nia years while just 6 did so in El Nino years, suggesting that both phases of the El Nino-Southern Oscillation are involved in the development of cold waves in the area. Based on the analysis, cold wave occurrences typically lasted ~ 9.6 days in northwest India. The longest episode ever was 26 days long and occurred in the year 2008, while the smallest episode ever was 6 days long and occurred in the year 2006. An interesting observation was that severe cold wave occurrences had an average length that was 4 days longer than that of typical cold wave episodes.

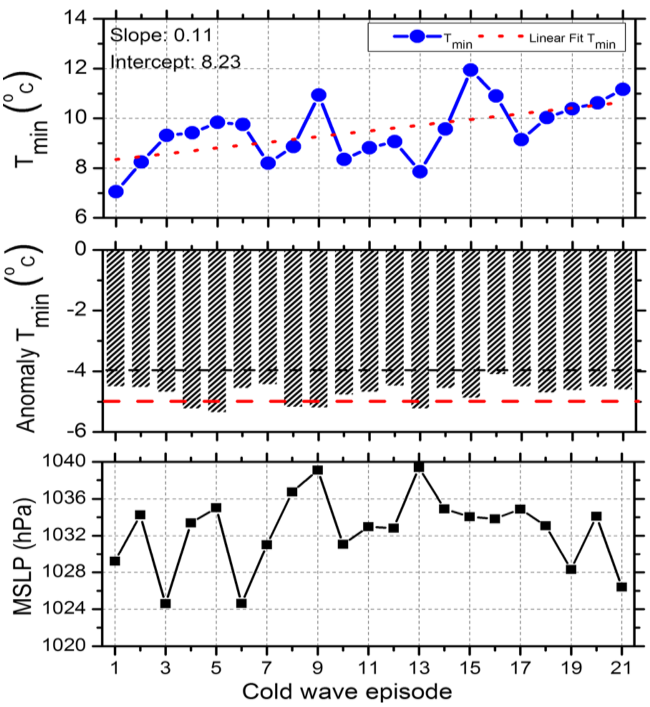

Fig. 1. *Time series of area-averaged Tmin, Tmin anomaly, and MSLP, illustrating the intra-annual variability of cold wave episodes for the study period.*

Also in 2005, the earliest cold wave onset was recorded on December 11, while the latest onset was recorded on February 16. The Siberian anticyclone and the western disturbance, which were the main causes of the cold winds in the study region, were also highlighted in the study. Anomalies in Geopotential height and temperature advection were also noted as important factors in the development of cold waves. The study also showed that there was significant intra-annual variation in the intensity of the cold waves in northwest India, with an increase of 0.11°C per cold episode. To assess the presence of intra-annual variability in cold waves (CWs) and identify any trends, an average of the minimum temperature (Tmin) over a specific area was calculated, along with its corresponding anomaly (Fig. 1). The dashed black (red) lines represent the Tmin climatological - 4°C (- 5°C). The average was taken for MSLP over (40°–60°N, and 70°–120°E) region, whereas for Tmin over the study region (Sandeep and Prasad, 2020).

Another study was performed by Singh et al. (2021) based on the comprehensive evaluation of three newly-developed high-resolution reanalysis datasets (IMDAA, NGFS, ERA5) in comparison to IMD rainfall observations during 1999-2018 over the Indian homogeneous monsoon regions.

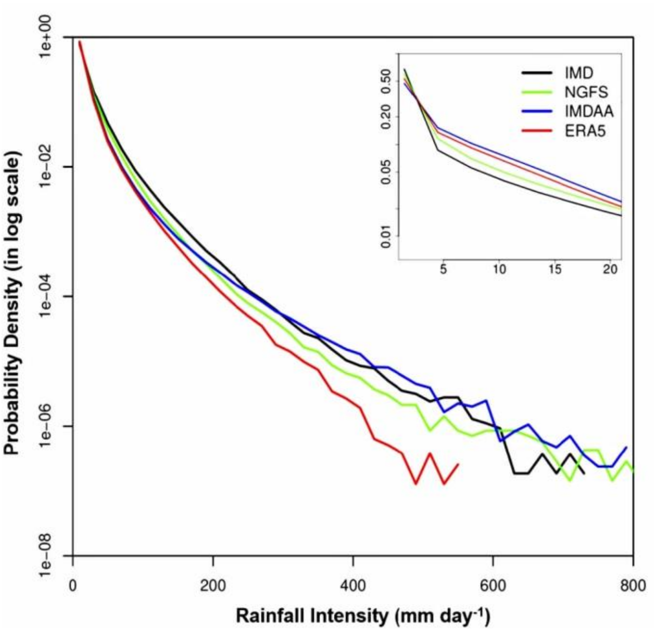

Fig. 2. *Probability Distribution for the rainfall intensity of IMD, IMDAA, NGFS and ERA5 reanalysis data respectively. Similar curve for light rain category is shown in the inset.*

The study delineates that both IMDAA and NGFS reanalysis captured the region-specific moist and desiccated trends, which is in alignment with observational trends. Moreover, both these IMDAA and NGFS reanalysis diligently captured the probability distribution of daily rainfall intensity, particularly within the range of extremes, while ERA5 reanalysis underestimated it (Fig. 2). Reasonably, NGFS performed comparatively well in capturing heavy and very heavy rainfall over the Western Ghats, surpassing IMDAA and ERA5 reanalysis. In contrast to IMDAA and NGFS reanalysis, ERA5 exhibited underestimation for all categories of extreme rainfall, as confirmed by the probability distribution curve.

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