

**Meteorological causes of observed extreme precipitation trends in the U.S.**

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Trends in the type of meteorological events responsible for the documented increases in U.S. heavy precipitation during the latter part of the 20th Century have not been identified. This study is investigating whether there have been secular changes in the frequency, intensity, and other characteristics of the meteorological phenomena producing heavy precipitation. A set of 930 long-term stations, distributed throughout the U.S., was used to identify heavy precipitation events over the period of 1908-2009. Heavy precipitation events were defined as 1-day precipitation totals exceeding the threshold for a 1 in 5 year recurrence. A total of 20,242 events were examined. The meteorological cause of each event was identified as one of the following: extratropical cyclone near a front (ETC-FRT), extratropical cyclone not near a front (ETC-NFRT), tropical cyclone (TC), mesoscale convective system (MCS), air mass convection (AMC), North American Monsoon (NAM), and upslope flow (USF). Several datasets were employed to determine the cause including reanalysis data, surface fields of temperature and precipitation, and cyclone tracks. The identification was made by the judgment of the authors. The result of this effort is a catalog of heavy precipitation event causes. Initial analysis of this new set of data reveals the following key points: - The percentage of events ascribed to each cause were 68% for ETC-FRT, 13% for ETC-NFRT, 8% for TC, 6% for MCS, 1% for NAM, 1% for AMC, and 0.1% for USF - The overall upward trend in the frequency of heavy events is primarily a warm season phenomena, and concentrated in the late summer/early fall - The upward trends are concentrated in the eastern half of the U.S., most notably in the southeast - The upward trends appear to be largely driven by increases in events associated with fronts and tropical cyclones - The recent (last 25 years) elevated level of frequency of occurrence is accompanied by increases in the precipitable water associated with events in the warm season - The precipitable water and upward trends in heavy event frequency increases are most notable in the southeast U.S. These points are suggestive that increases in water vapor may be a primary cause. For example, landfalling tropical cyclones have not increased despite increases in associated heavy precipitation events, suggesting increased water vapor availability for each cyclone. In addition, mean water vapor has increased during the last 25 years in the warm season.