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Development of a 60-Year Gauge-Based Analysis of Hourly Precipitation for the Conterminous United States

2010

Abstract: Numerous observational studies have documented changes in the amount, intensity, frequency, and type of precipitation during the 20th century in the United States. Likewise, various model-based analyses indicate that the spatial-temporal distribution of precipitation may change considerably during the 21st century. Of particular note, an increased frequency in heavy rainfall events is expected over many regions, likely resulting in the more frequent occurrence of major flood events.

Long-term precipitation datasets, with appropriate time and space resolution, are required to accurately document long-term trends in extreme precipitation. Virtually all published long-term trend studies, however, are based on monthly and daily records. While such data provide some perspective on long-term changes (e.g., in drought, daily extremes), variations at the sub-daily level must be examined to truly understand the physical causes and societal impacts of precipitation extremes. Among a number of areas identified in the Intergovernmental Panel on Climate Change Fourth Assessment Report where uncertainty is highest and additional attention required includes analysis and monitoring of extreme events including the frequency and intensity of precipitation. Specifically, longer data time-series of higher spatial and temporal were identified as a primary need for addressing this deficiency.

In this project, we propose to construct a gauge-based analysis of hourly precipitation over the conterminous United States (CONUS) for a 60-year period from 1948 to the present. We will then use the data set to examine heavy precipitation events and their long-term changes. The first step of this project will involve the creation of a baseline hourly precipitation analysis on a 4kmx4km grid over CONUS for the period 1998-present. This will be accomplished by combining Stage-II radar observations, satellite estimates (CMORPH), and gauge reports (NCDC/DSI-3240, HADS). A gauge-based analysis will be created by interpolating hourly reports from all sources. Biases in the radar and satellite precipitation estimates will be corrected through matching the probability density function (PDF) of the radar/satellite data with that of the collocated gauge data. Bias-corrected radar/satellite estimates will then be combined with the gauge analysis through the optimal interpolation (OI) technique to form the hourly precipitation analysis. There is a twofold purpose in creating this baseline analysis for 1998-present. First, it will provide a set of criteria for selecting gauge stations in the interpolation process for the 60-year gauge-only analysis. Second, it will facilitate the quantification of network-based uncertainty in the 60-year gridded fields. Uncertainty will be assessed by interpolating gauge reports from various combinations of available stations. The performance of these sub-networks will then be compared with the _truth' (i.e., baseline analysis) to assess their quantitative

accuracy, i.e., their ability to: a) represent hourly precipitation as a function of precipitation intensity, network density, calendar season, geographic location, and size of averaging domain; b) capture extreme events as measured by the fidelity of the PDF of area-averaged precipitation intensity over a grid box; and c) identify biases and aliases in long-term changes in the frequency and spatial distribution of extreme events caused by insufficient networks (and changes therein).

The uncertainty assessment will then be used to guide the development of the gauge-based analysis of hourly precipitation for the full 60-year period. Gauge reports will be selected from the NCDC/DSI-3240 data set. The grids themselves will be created by interpolating selected station reports through an OI-based objective analysis algorithm with consideration of orographic effects (Xie et al., 2007). An estimation of random error will be included for each grid box and for each hourly precipitation analysis. Seasonal trend uncertainty estimates will also be developed.

Finally, we will examine the frequency, intensity, and duration of extreme events using the multi-sensor merged analysis for 1998 to the present for an accurate documentation of the modern era, and the gauge-only analysis for the depiction of long-term trends. The spatial distribution and temporal variations of precipitation extremes will be investigated in association with seasonal variations, short-term climate variability (ENSO, MJO, NAO), and long-term changes. Uncertainties will be considered in performing these examinations. We will also compare our results with precipitation fields from reanalyses, CMIP5 coupled simulations, and other climate models.