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Urban Flood Demonstration Program

Implications of Non-Stationarity of Flow and Volume Frequency Statistics on Flood Risk

Products A technical report describing the findings of the effort's research into defining the implications of non-stationarity of flow and volume frequency statistics that are currently used to quantify flood risk.

Benefits This effort seeks to quantify the effect of climate change on the statistics of extreme precipitation events at the catchment and regional scales and the resultant effect on flow and volume frequency in ephemeral channels in the Albuquerque, Phoenix, and Las Vegas regions.

Issue Climate change has the potential to impact flood risk through a number of mechanisms, including change in precipitation type and timing, changes in snowmelt timing, and increased frequency of extreme events. If climate change alters streamflow regimes, then stationarity-based flow and volume frequency models currently used for project design may not apply.

Description This research effort will be carried out by means of the following subtasks:

1) Regional frequency analysis from existing climate models

Regional frequency analyses (both for precipitation stations and regional climate model grid boxes) are known to be more accurate statistical estimates than local analyses (Mailhot et al. 2007). We will investigate the impact of future climate change on the intensity-duration-frequency (IDF) curves for arid/semi-arid regions of the U.S. Regional climate model results should be interpreted at a regional scale (integrating many grid boxes) since grid boxes only represent the simulation ''fundamental'' spatial unit.

2) Spatial scale issues connecting grid box scale to station scale

IDF curves are usually developed from site-specific records. Therefore, methods are needed to estimate rainfall intensities at the station scale from the estimated values at the climate grid box scale. We will establish an areal reduction factor (ARF) to relate the maximum areal average rainfall intensity to the maximum rate estimated at a precipitation station scale in the semi-arid southwestern United States.

3) Multiscaling rainfall variability model

Inter-annual and inter-decadal climate variability linked to large scale climatic oscillations such as El Nino-Southern Oscillation and Pacific Decadal Oscillation (PDO) is correlated with flood events and affects flood frequency analysis (Pizarro and Lall 2002, Tootle et al. 2005). Rainfall variability in the major urban areas of the southwestern U.S. will be studied and modeled using both gauge data and climate model projections at the within-storm, seasonal, annual and multi-decadal scales.

4) Rainfall-runoff based flood frequency analysis

Repeated realizations derived from the stochastic (multiscaling) rainfall model developed in task 3) will be used as input to deterministic rainfall-runoff models such as the

Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) and the Gridded Surface Subsurface Hydrologic Analysis (GSSHA). Output will be used to develop flow frequency statistics for catchments subject to a new rainfall variability regime.

5) Volume frequency in ephemeral channels under a changing climate

In a previous, high-priority UFDP task, we determined that volume frequency of channels in the arid southwest is dependent not just on statistics of peaks, but also on event duration because the majority of the hydrograph is not contained under sharp flash flood peaks. Thus, volume frequency statistics will respond to changes in antecedent moisture conditions (storm frequency) and storm duration. Changes in precipitation statistics derived under subtasks 1) and 2) will be used to anticipate changes in volume frequency statistics to inform planning and design studies.

Sponsor

Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

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