When do Flash Floods Occur in Hawaii?

- 414 events in 46-year period
- 9 per year
- Causes most of the direct wx-related fatalities
- November is the worst month for storms (1-2 flash floods)
- June has the best weather

Ingredients for Heavy Rain

- Moisture – lots of water vapor
  - Large amounts of moisture results in unstable air and more rainfall
- Large upward motion
  - Low level convergence & upper level divergence needed for heavy rainfall.
- Slow storm motion (i.e. long duration)
  - Increases total rainfall over basin
  - terrain anchoring

Upper Level Divergence of Winds

- Analysis for 1200 UTC 25 January 1996 of 250 mb streamlines and isotachs (every 5 m/s).
Low Level Convergence of Winds

• Analysis for 1200 UTC 25 January 1996 of sea-level pressure (mb).

Terrain Affects

• Terrain lifting and anchoring
  – Ideal lifting mechanism for prolonged heavy rains
  – Rain maxima often over slopes exposed to low level flow

• Lee-side convergence zones (a.k.a. “plumes”)
  – Enhanced low level convergence.
  – Southeasterly flow causes “plume” to drift over downstream islands

Hana Flood

Big Island Plume and Terrain Anchoring

Hana Flood

Big Island Plume and Terrain Anchoring
Four Heavy Rain Patterns: Provide Moisture and Upward Motion

- Cold front passage
- Kona low
  - Slow moving storm
  - Ample upward motion
  - Brings in moisture from deep tropics
- Upper-level low or trough
  - over tropical system or its remnants is very dangerous. e.g., Nov 2000 Flood
- Tropical Cyclone
  - tropical storm
  - hurricane

Factors that Contribute to Flood Problem

1. Small Watersheds result in short response time.
   - Steep slopes increase speed of runoff
   - Shallow soils quickly become saturated
2. Urbanization increases runoff.
   - debris dams commonly form in urban culverts
   - storm water and sewers share plumbing - result is sewage spills.

Small Basins mean Short Response Time

- Small basins with steep slopes and shallow soils make the time between peak rain and peak discharge short, as little as 15 minutes. Half of the State is within 5 miles of the shore, therefore lead time for a response time is very short.

Some Notable Flood Events

- November 2000
  - SE and E Big Island
  - $70 Mil.
  - 37 inches/24-hrs (22 in./6-hr)
- Dec 1991 Anahola Flood
  - East Kauai
  - $5 Mil. & 4 fatalities
- Dec 1987/Jan 1988 “New Years Flood”
  - East Oahu
  - 22 inches/24-hrs
  - $34 Mil.
- March 2006
  - Kaloko Dam Break - seven deaths

Bridge washout on Komohana St. in Hilo the day after the Nov. 2000 Big Island flood event.
Manoa Halloween Flood 2004

Rainfall Rates
15min: 1.29 inches
1-hr: 3.72 inches
2-hr: 4.38 inches
3-hr: 5.73 inches
6-hr: 8.71 inches
A once in 50-yr storm

Oahu New Year’s Eve Flood


24-hour rainfall in inches. Distribution determined by the terrain.

Rainfall Distribution: New Year’s Storm

Hahaione Washout

Contours for a 100-yr rainfall event with overlay of 20” rainfall contour.
Kaloko Dam Break

- Caused seven deaths
- Over 120 dams in the State of Hawaii
- Most are earthen dams, 70 to 90 years old, built to support agriculture

Kaloko Reservoir, Kauai
Extreme value theory is a branch of statistics dealing with extreme deviations from the median of probability distributions. The general theory sets out to assess the type of probability distributions generated by processes. Extreme value theory is important for assessing risk for highly unusual events, such as 100-year floods.

Emil Julius Gumbel (1958) showed that for any well-behaved initial distribution (i.e., $F(x)$ is continuous and has an inverse), only a few models are needed, depending on whether you are interested in the maximum or the minimum, and also if the observations are bounded above or below.
The Likelihood of Extreme Events

The Gumbel distribution is a special case of the Fisher-Tippett distribution (named after Sir Ronald Aylmer Fisher (1890–1962) and Leonard Henry Caleb Tippett (1902–1985), also known as the log-Weibull distribution. The cumulative distribution function of the Fisher-Tippett distribution is

\[ F(x; \mu, \beta) = e^{-e^{(\mu - x)/\beta}} \]

which can also be written

\[ F(x; \mu, \beta) = e^{-e^{(\mu - x)/(\mu - M)}} \]

where \( M \) is the median, \( \kappa \) is a shape parameter, \( \beta \) is a scale parameter and \( \mu \) a location parameter.

To obtain recurrence intervals, first a series of extreme values must be obtained from the historical data set (e.g., series of yearly maxima of daily rainfall total). Then a generalized extreme-value cumulative-distribution function (eq. 2) is calculated from this series. This function contains shape, location, and scale parameters that are estimated based on the temporal length and distribution of values contained in the dataset. To fit values one can get the median straight away and then vary \( \mu \) until it fits the list of values.

Questions?