Statistical Analysis of Flooding of Streams near Dubuque, Iowa

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Data available online from USGS gauging stations provide opportunities for student analysis of flooding using basic statistics. For example, last semester students at the University of Dubuque analyzed flood data from the Grant River near Burton, Wisconsin. As the students graphed the data, it became apparent that the most extreme floods did not follow the normal distribution, though that distribution fit quite well most other peak floods. Further inspection of the data showed those floods to have occurred in June and July. However, flooding on the Mississippi River is dominated by spring runoff from snowmelt, with the most extreme discharges occurring in April. This observation led to the hypothesis that the most extreme flooding in small watersheds in the Wisconsin-Iowa area that drain to the Mississippi River is due to localized convection cells during the summer. Larger watersheds are dominated by snowmelt. This hypothesis was tested by analyzing USGS peak annual discharge data for 11 gauged streams that enter the Mississippi River closest to Dubuque.
Analysis techniques included standard exceedance-probability versus discharge plotting techniques and PeakFQ, a U.S.G.S. program for fitting log-Pearson Type III distributions. Summer floods dominated the most extreme events in small watershed but less so in larger ones. In addition, ENSO events were found to be correlated with winter flooding (α=.05) but not with summer flooding. An impact of ENSO events upon flooding both worldwide and in California has been previously documented but, to the author's knowledge, not specifically in the upper Midwest.

Introduction

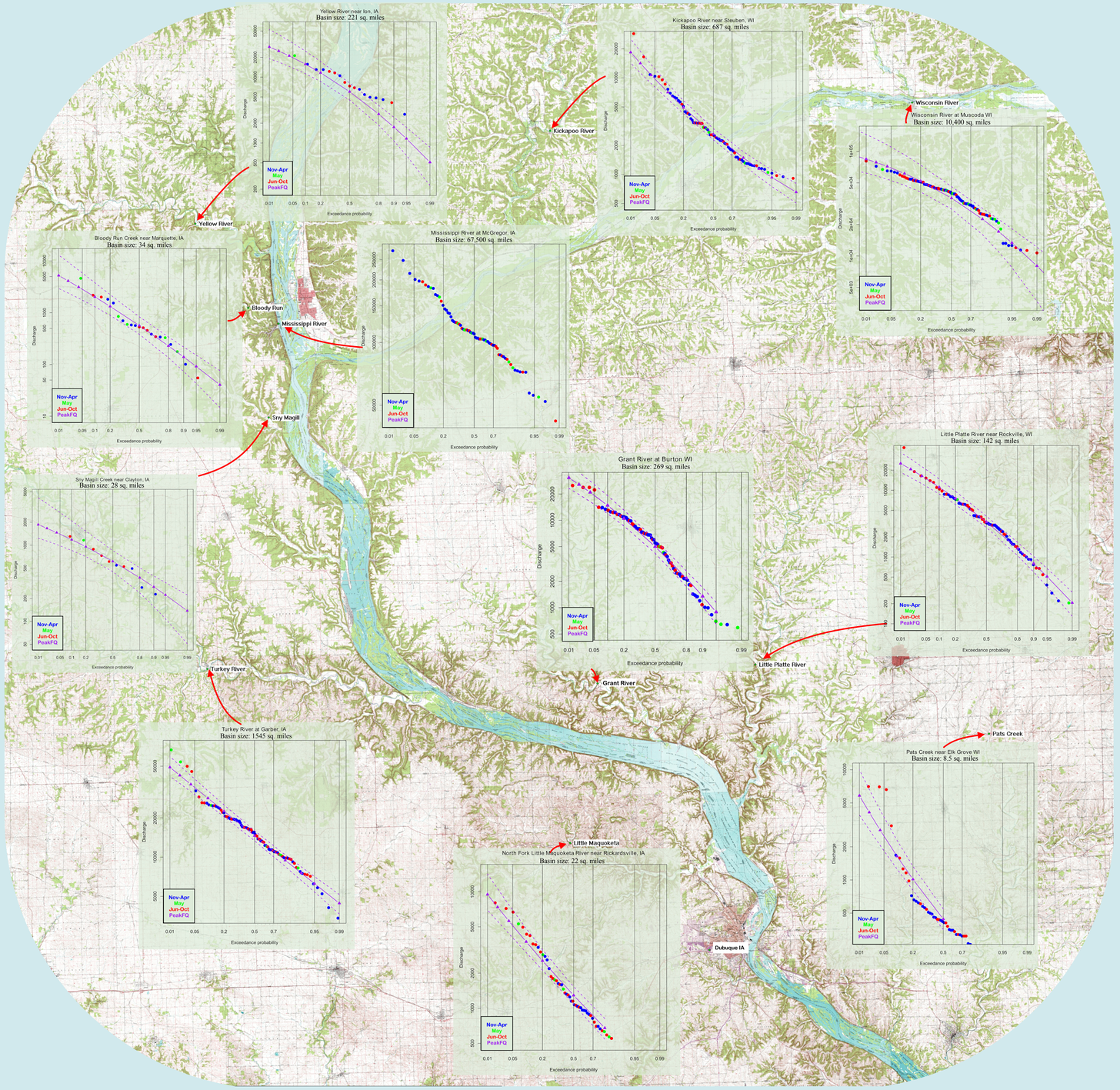
- Two main processes control flooding events in the Dubuque area:
  - Snowmelt
  - Convection-driven summer storms
- Snowmelt flooding is widespread but convection-driven are often localized
- Flooding worldwide (Ward et al., 2013) and in California (Cayan et al., 2005) have been shown to be correlated to ENSO events (El Niño–Southern Oscillation)
- These observations plus an examination of data from USGS stream gauges in the Dubuque region led to two hypotheses:

1) *The most extreme flooding in small watersheds in the Wisconsin-Iowa area that drain to the Mississippi River is due to localized convection cells during the summer while larger watersheds are dominated by snowmelt; and*
2) *Flooding due to snowmelt is correlated with ENSO events.*

Methods

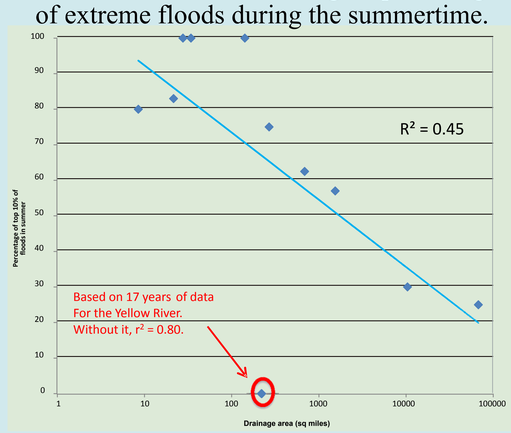
- Obtained annual peak discharge data and watershed size from USGS gauging stations plus ENSO series from NOAA
- Plotted and calculated exceedence probabilities:
  - PeakFQ with Log-Pearson Type III distribution
  - Log-normal plots of rank versus discharge
- Determined time of year of peak floods
- Separated peak floods in June–October from November–April
- Determined percentage of top 10% of peak floods that occurred in June–October versus November–April
- Performed regression on resulting percentages versus watershed size
- Checked correlation of ENSO events to summer and winter floods for Grant River data

Results



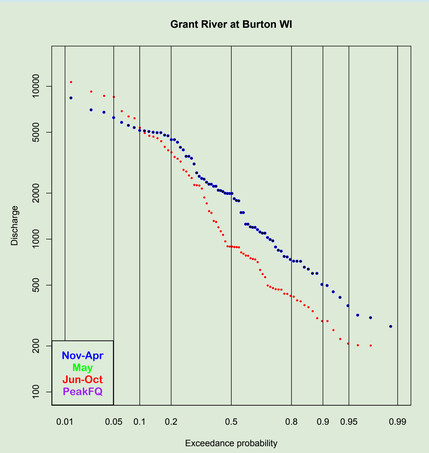
Discussion

- Small watersheds have a higher percentage of extreme floods during the summertime.



Drainage area plotted against percentage of extreme floods in summer, showing impact of drainage area and seasonality upon flooding.

- Accounting for seasonal effects alters exceedance probabilities.



Standard plot of exceedance probability with winter and summer extreme events, based on highest daily average per year.

- ENSO events for Feb-Mar are significantly correlated (P=0.05) with snowmelt floods for the Grant River.

Selected References

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