Riverine Flooding and Landfalling Tropical Cyclones over China

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1. Background

- Typhoon Nina (1975) was responsible for the August 1975 flood over central China, one of the most destructive floods in world history. The August 1975 flood plays an important role in shaping the envelop curve of flood peaks over China and the world.
- China is located on the margin of the Western North Pacific (WNP) basin, and experiences some of the most severe impacts from landfalling TCs in the world. Little is known about the spatial variability of tropical cyclone (TC) induced inland flooding across China.
- The main objectives of this present study are (1) to characterize the spatial variability of landfalling TCs and extreme floods associated with them, and (2) to investigate dominant synoptic drivers that determine severe TC-flood hazards over China.

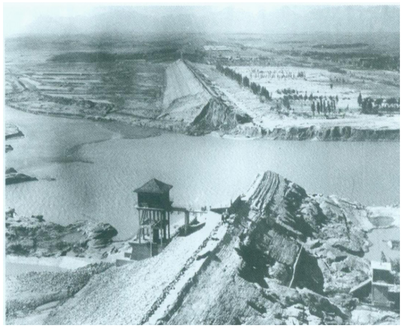

Figure 1. The collapsed Banqiao reseservoir due to Typhoon Nina in August 1975.

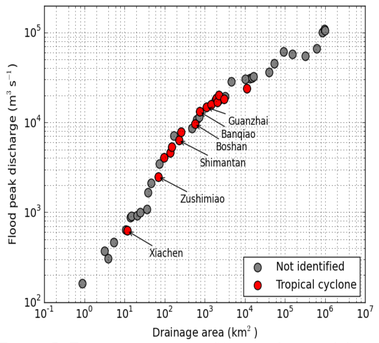

Figure 2. The envelope curve of the maximum rainfall–runoff floods over China.

2. Data and Methods

- We associate an annual flood peak with a particular TC if the circulation center is within 500 km of the station during a time window of two days prior to or a week after the timing of flood peak.
- We use the notion of flood ratio, i.e., the magnitude of flood peak associated with TCs divided by the sample 10-year flood for a given station, to provide a regional perspective of TC flooding.

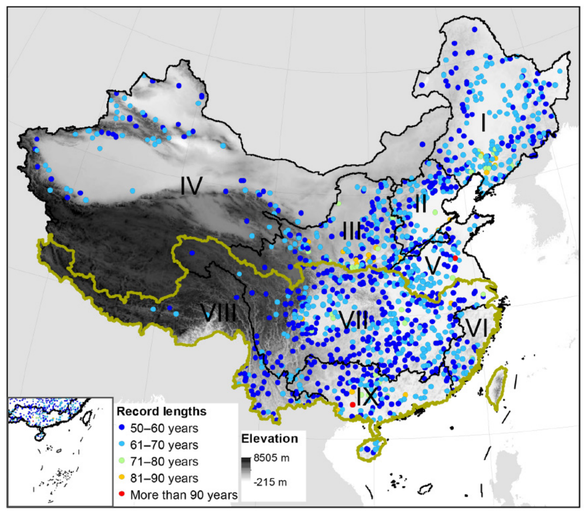

Figure 3. Overview of the stream gauging stations with record lengths of more than 30 years over China (1620 gauges in total).

3. Spatial Variability of TCs and TC-Floods

- Both the number of landfalling TCs (Figure 4a) and the percentage of annual TC flood peaks (Figure 4b) exhibit spatial gradients decreasing from coastal towards inland regions.
- The noticeably high probablity of TC flood peaks in central and northeastern China (Figure 4c) indicates that a TC will most likely lead to the largest floods for the year as long as it can "survive" into inland region after landfall.
- Extreme floods in central and northeastern China are determined by TCs despite infrequent visits compared to the southeastern coast (Figure 4d).

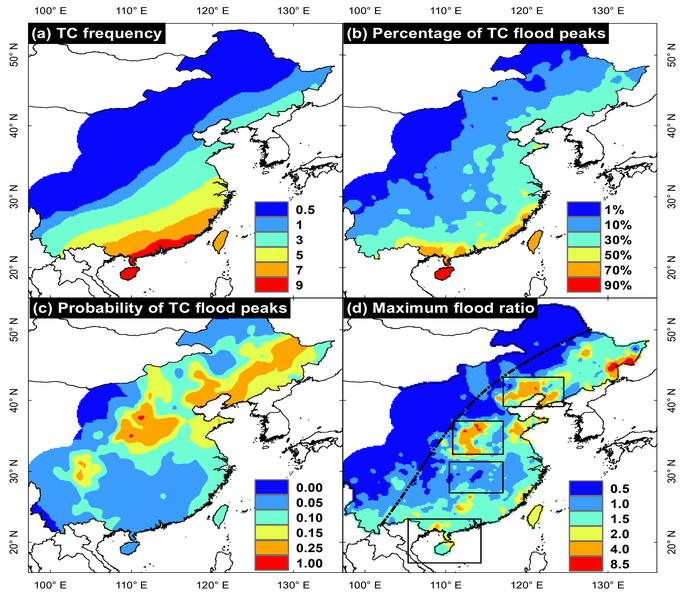

Figure 4. (a) TC frequency, (b) percentage of TC flood peaks, (c) probability of TC flood peaks, and (d) maximum flood ratios

4. Examples of Severe TC Floods

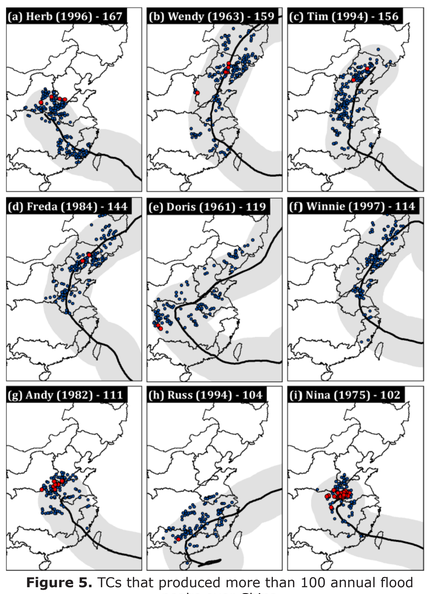

Figure 5. TCs that produced more than 100 annual flood peaks over China

- The nine TCs contribute to 50% of TC-induced annual flood peaks over China.
- The nine TCs can be categorized into two different types:
- **Group 1**: TCs are characterized by two landfalls; Tracks do not fall into the prevailing TC tracks in the western North Pacific basin; Role of complex terrain in central China. (Figure 5a, 5g, 5i)
- **Group 2**: Extratropical transition during the life cycle of the storms; Annual flood peaks frequently occurred after extratropical transition. (Figure 5b, 5c, 5d, 5e, 5f, 5h)

5. Role of Climate Controls in TC Floods

- The severity of flood hazards shows strong contrasts in the spatial patterns of TC tracks.
- Severe TC flood hazards are characterized with land surface temperature below the climatological mean in the northern hemisphere, and sea surface temperature above the climatological mean in a large portion of the WNP basin.
- Anomalies in surface temperature through perturbed atmospheric circulation influence TC activities and moisture transport.

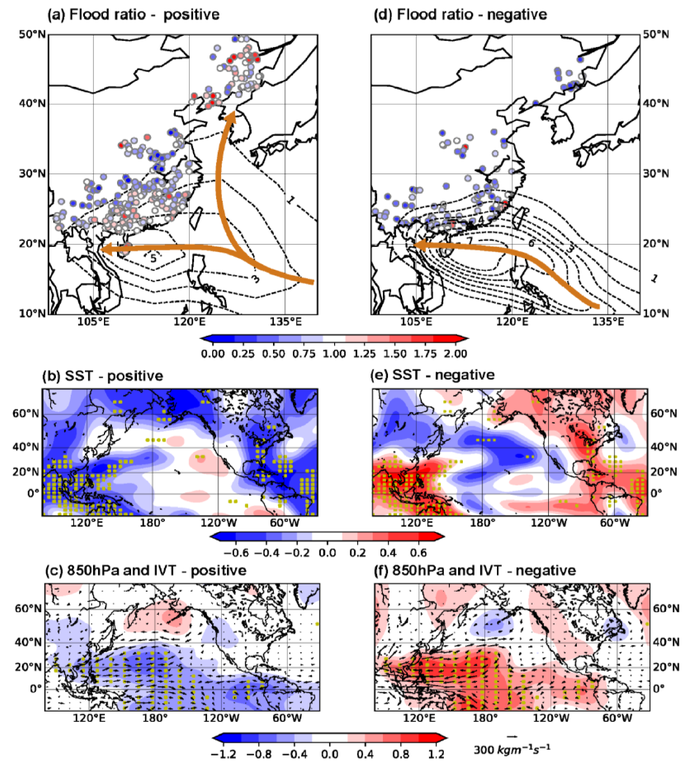

Figure 6. Maximum flood ratios and composite TC tracks during the years of positive and negative anomalies in the total number of TC-induced annual flood peaks over China.

6. Summary and Conclusions

- The most extreme floods in central and northeastern China are associated with infrequent TC visits.
- TC flood hazards over China demonstrate a combination of climate controls as represented by temperature anomalies in central tropical Pacific, western North Pacific and north Atlantic.
- Our results highlight physical links between severe flood hazards and large-scale synoptic features, and serve the basis for improved designs of flood-control infrastructures over China.

References:

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