Contributions of Historical Extreme Typhoon Events to Sediment Yield from Lin-Pien Watershed

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Contents

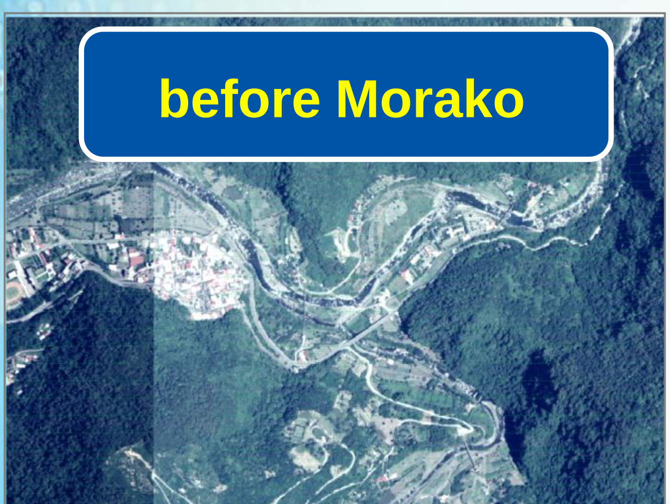
Introduction

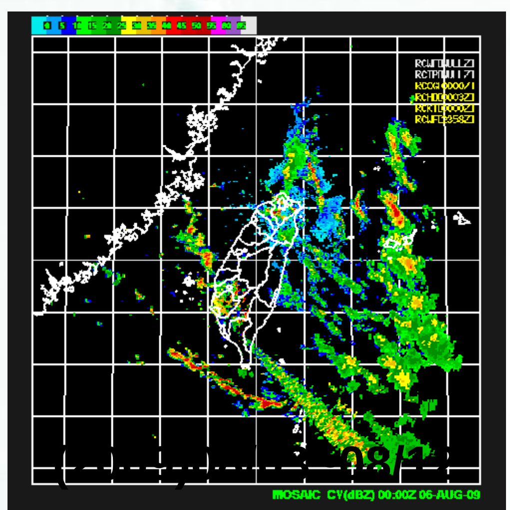
Due to the climate change, extreme climatic events occur more frequently around the globe; especially in the last decade.

Taiwan was unable to be excluded from this global phenomenon. **Weak geologic formation,** position in Pacific Fire Ring, abundant precipitation received from **summer typhoon** makes Taiwan be prone to natural disasters.

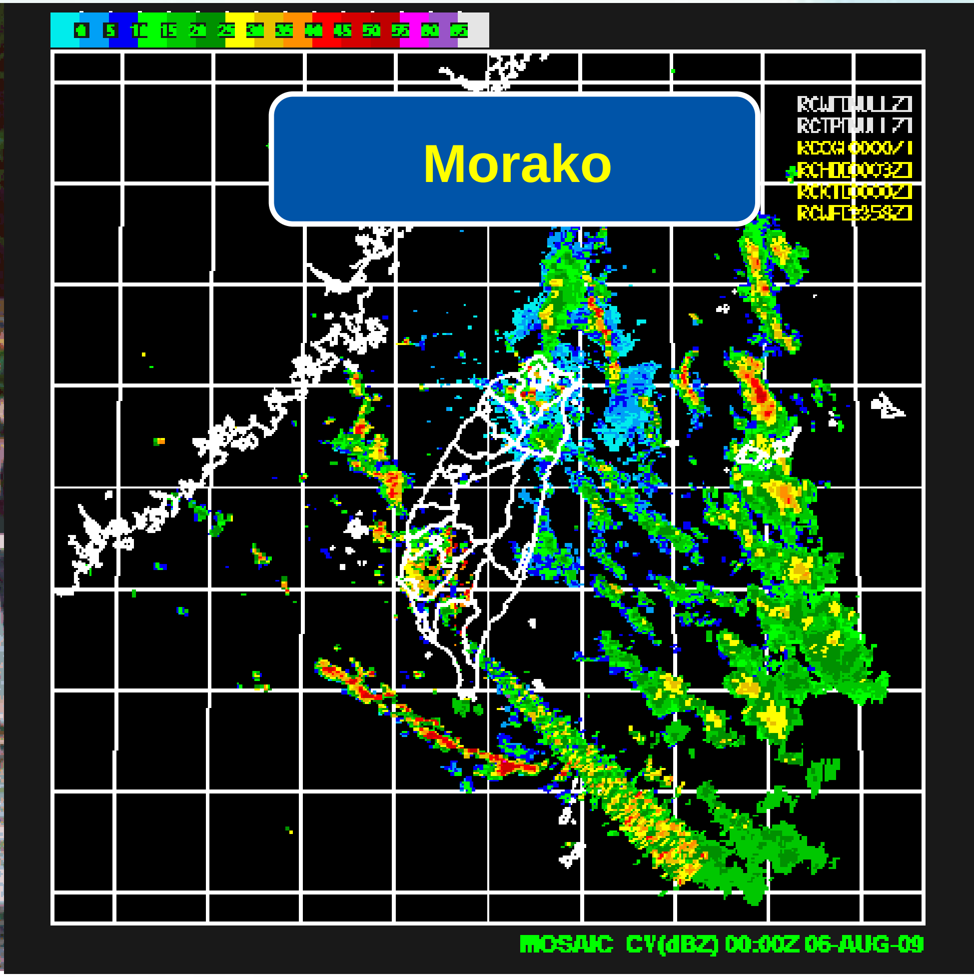
Introduction

The objective of this study is to investigate how climate change affects the occurrence and magnitude of extreme **typhoon** events as well as the sediment yield from **314,695 km^2 Lin-Pien** watershed.

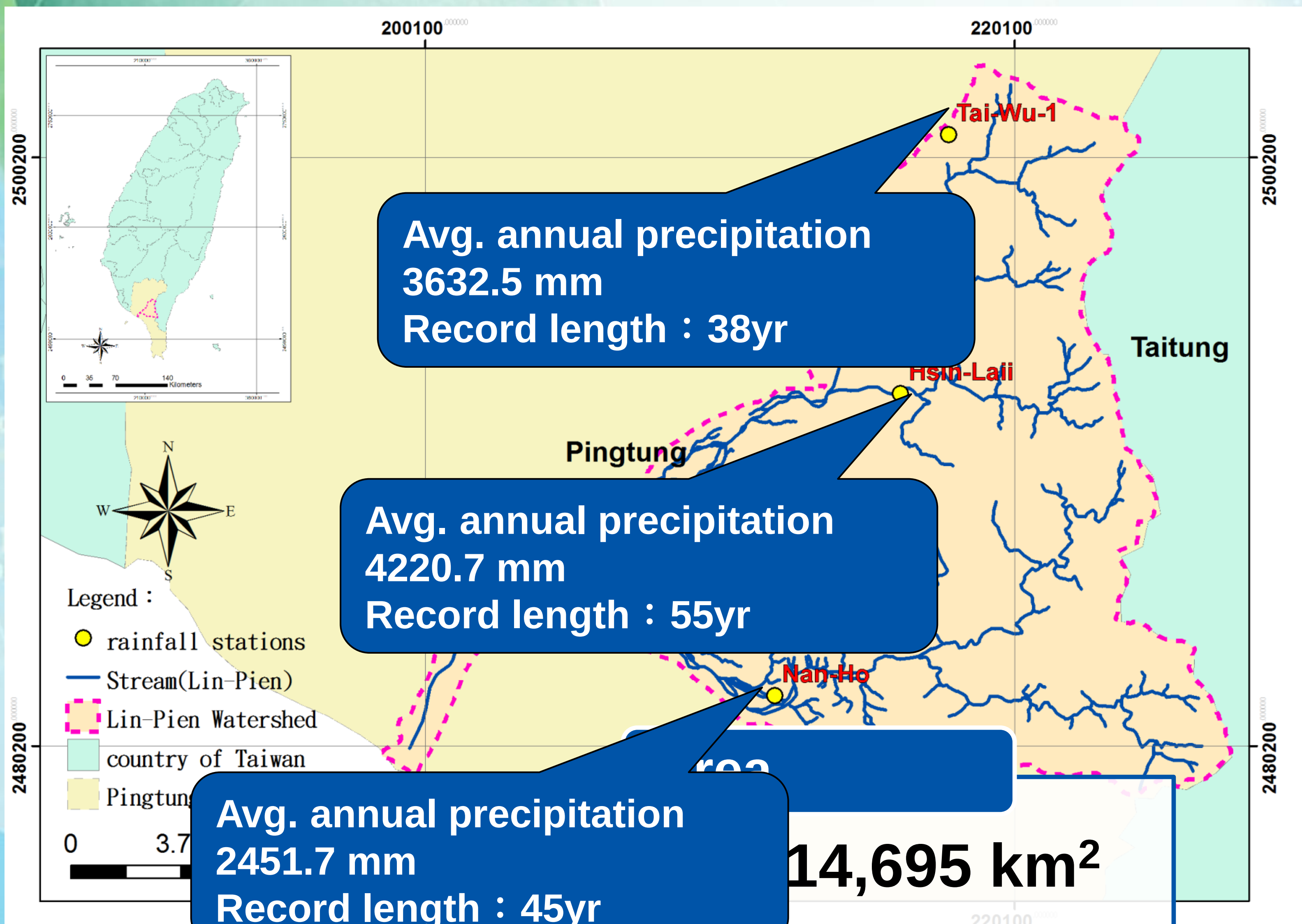




Introduction



Location and Geologic Formation



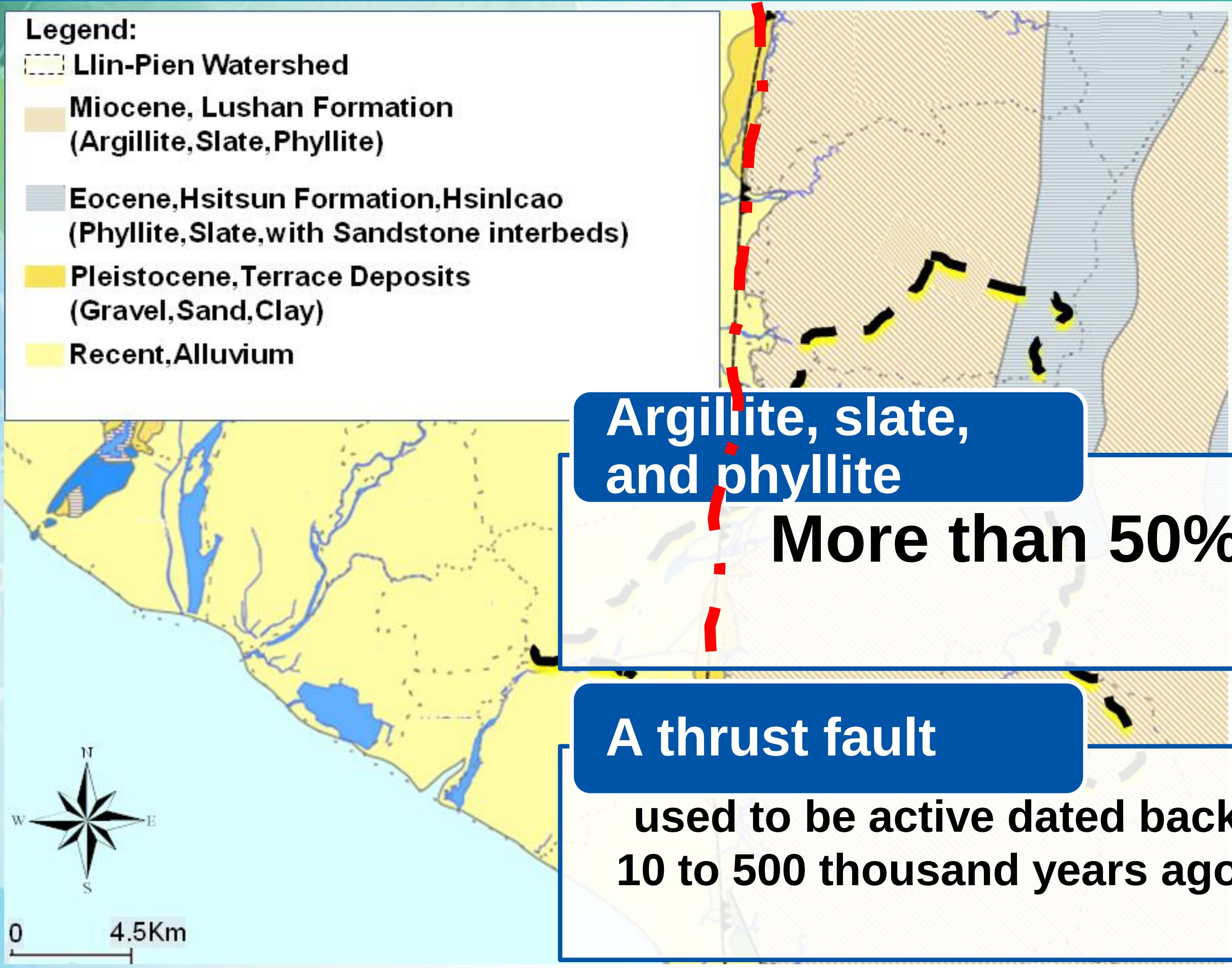
Avg. annual precipitation 3632.5 mm
Record length：38yr

Avg. annual precipitation 4220.7 mm
Record length：55yr

Avg. annual precipitation 2451.7 mm
Record length：45yr

14,695 km^2

Location and Geologic Formation



Argillite, slate, and phyllite

More than 50%

A thrust fault

used to be active dated back 10 to 500 thousand years ago

Data Sources

Suspended sediment concentration, **10-yr precipitation** records from three gauging stations, and **flow discharge** records gathered by Water Resources Agency at the outlet of the watershed was used to facilitate the analysis.

Antecedent Precipitation Index (API)

continuous rain without breaks

$$API = I_t \times K^t$$

I_t is rece t da

The first day t=0

rain ceases at (t-1) day

$$API = K \times API_{t-1}$$

API for (t-1) day

I_o is the total precipitation on day zero (mm)

rain ceases at (t-1) day but resumes at day zero

$$API = I_0 + K \times API_{t-1}$$

Data Sources

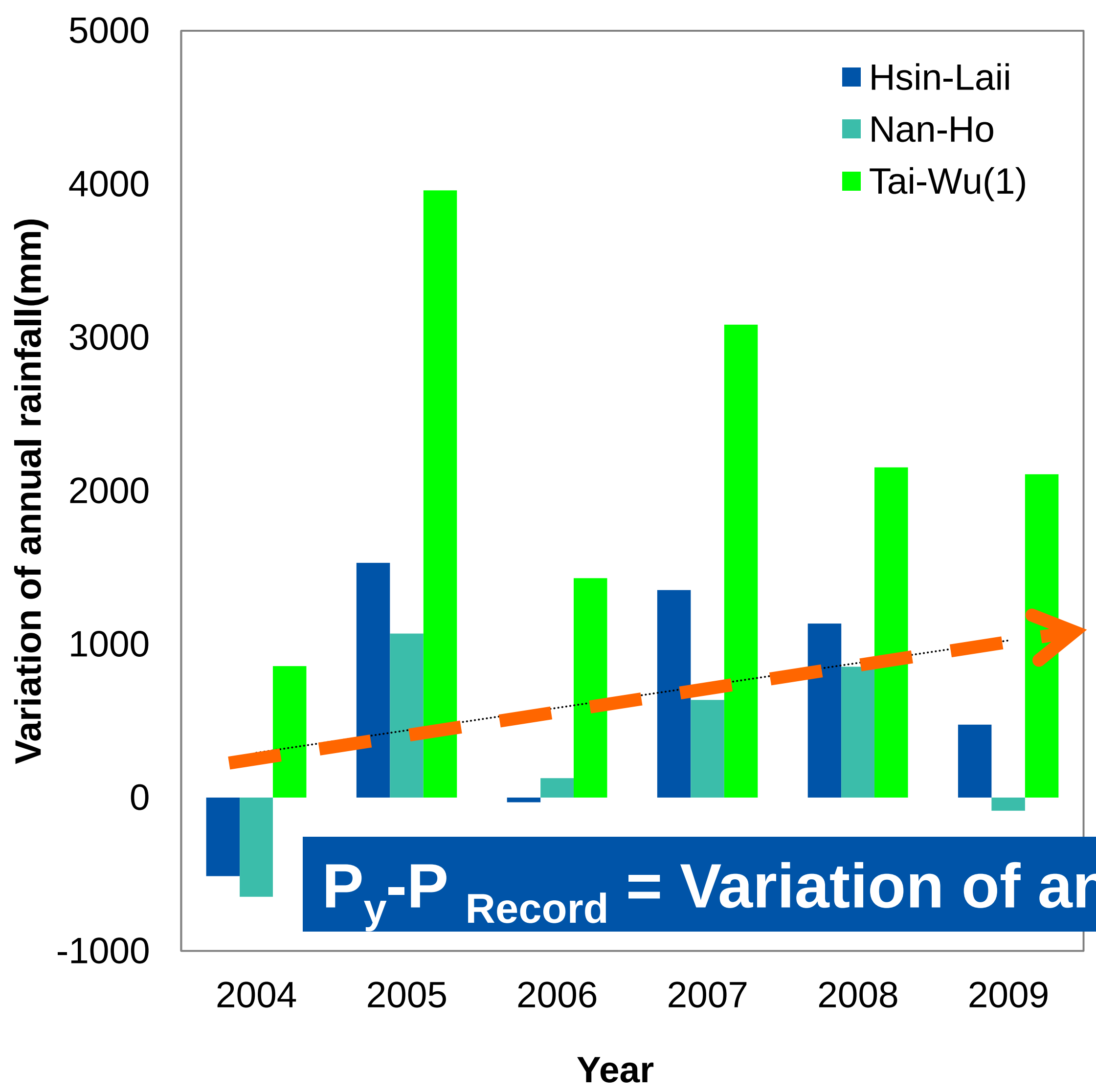
- **Typhoon events affecting Taiwan**
  - from 2004 to 2009
- **Suspended sediment**
  - sampled using DH-48 and DH-58 samplers
- **Precipitation**
  - Thiessen polygon method was used to estimate the average precipitation of the study watershed

Methods of Data Analysis

Anomaly method was used to analyze the trend of storm characteristics. Average annual precipitation from n-year records was first obtained.

Variation of annual precipitation; defined as the difference between annual and average annual precipitation; was calculated for the entire n-year records.

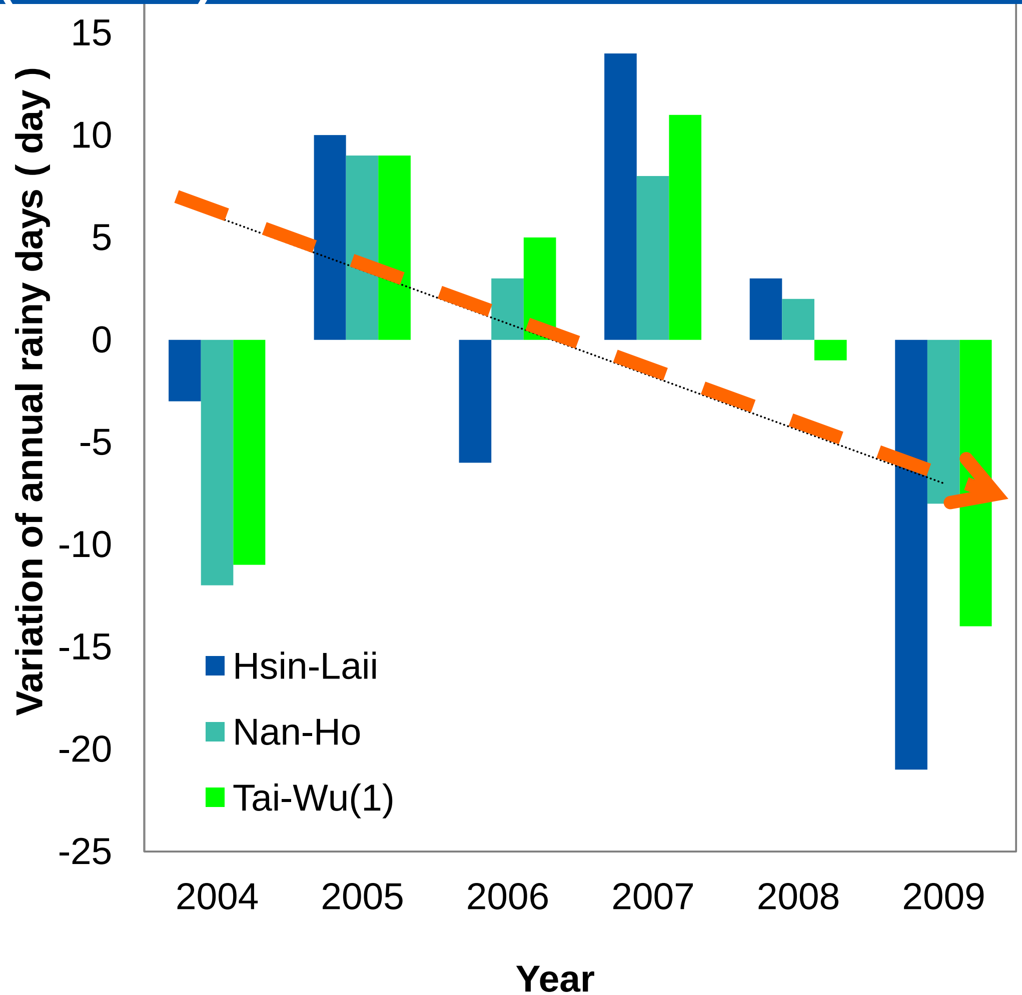
Variations of Annual Precipitation



P_y-P_{Record} = Variation of annual rainfall

Variations of Annual Rainy Day

D_y-$D_{(2004\text{-}09)}$ = Variation of annual rainy day

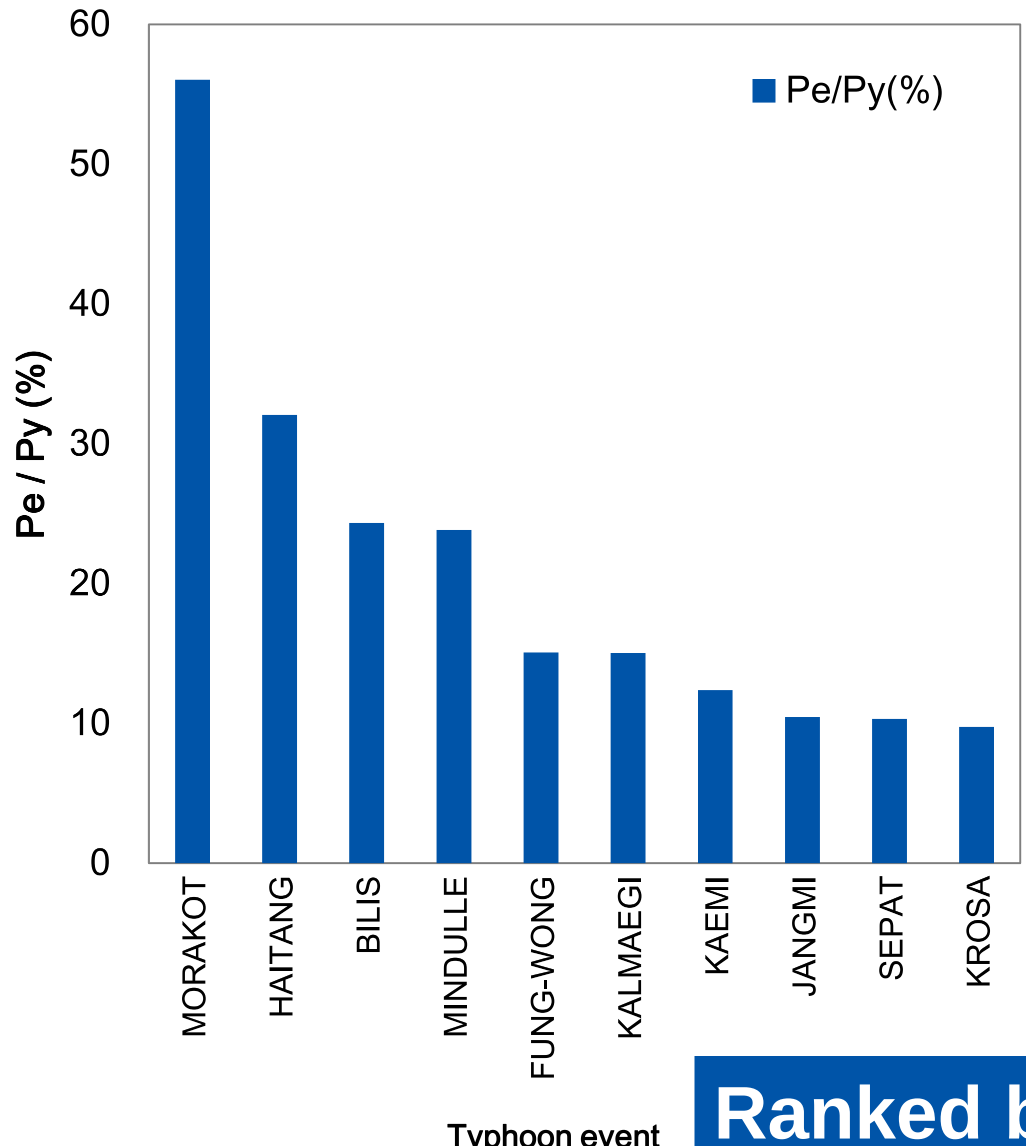


Top Ten Typhoon Events (2004~2009)

Ranking	Typhoon	Year of occurrence	Effective date	Total event precipitation Pe (mm)	Annual precipitation Py (mm)	Pe/Py (%)
1	Morakot	2009	08/05~10	2117.2	3777.7	56.05
2	Haitang	2005	07/16~20	1602.5	4997.5	32.06
3	Bilis	2006	07/12~15	857.9	3524.3	24.34
4	Mindulle	2004	06/28~07/03	695.0	2914.4	23.85
5	Fung Wong	2008	07/26~29	670.4	4448.8	15.07
6	Kalmaegi	2008	07/16~18	669.0	4448.8	15.04
7	Kaemi	2006	07/23~26	435.3	3524.3	12.35
8	Jangmi	2008	09/26~29	465.8	4448.8	10.47
9	Sepat	2007	08/16~19	475.7	4610.2	10.32
10	Krosa	2007	10/04~07	449.4	4610.2	9.75

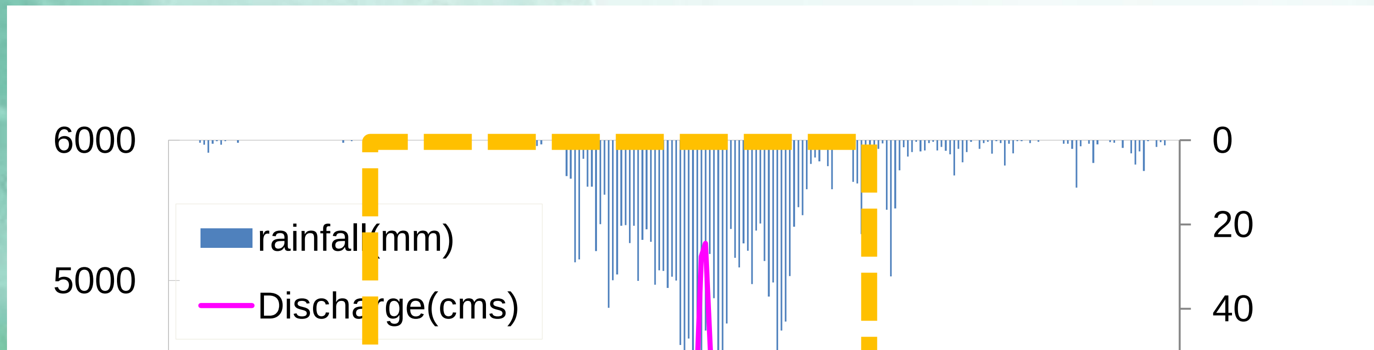
Ranked by Total Precipitation

Top Ten Typhoon Events (2004~2009)

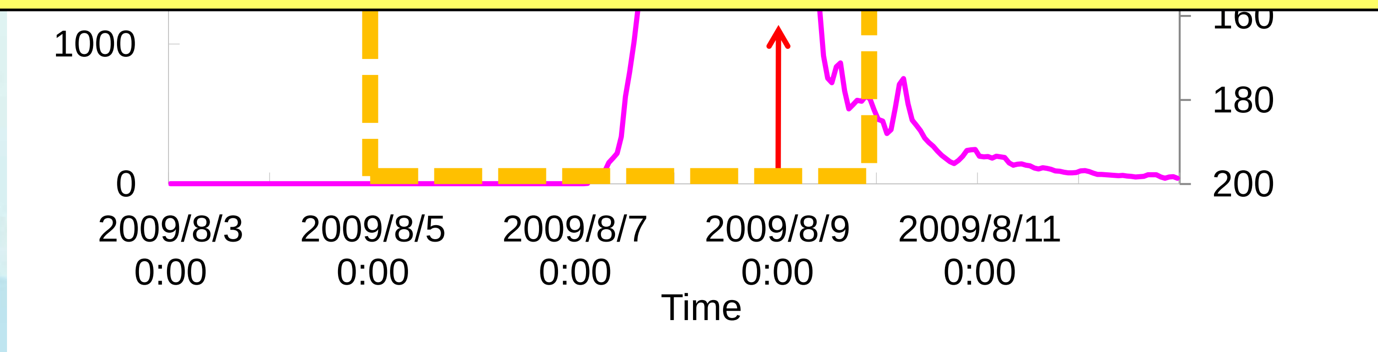


Ranked by Pe/Py

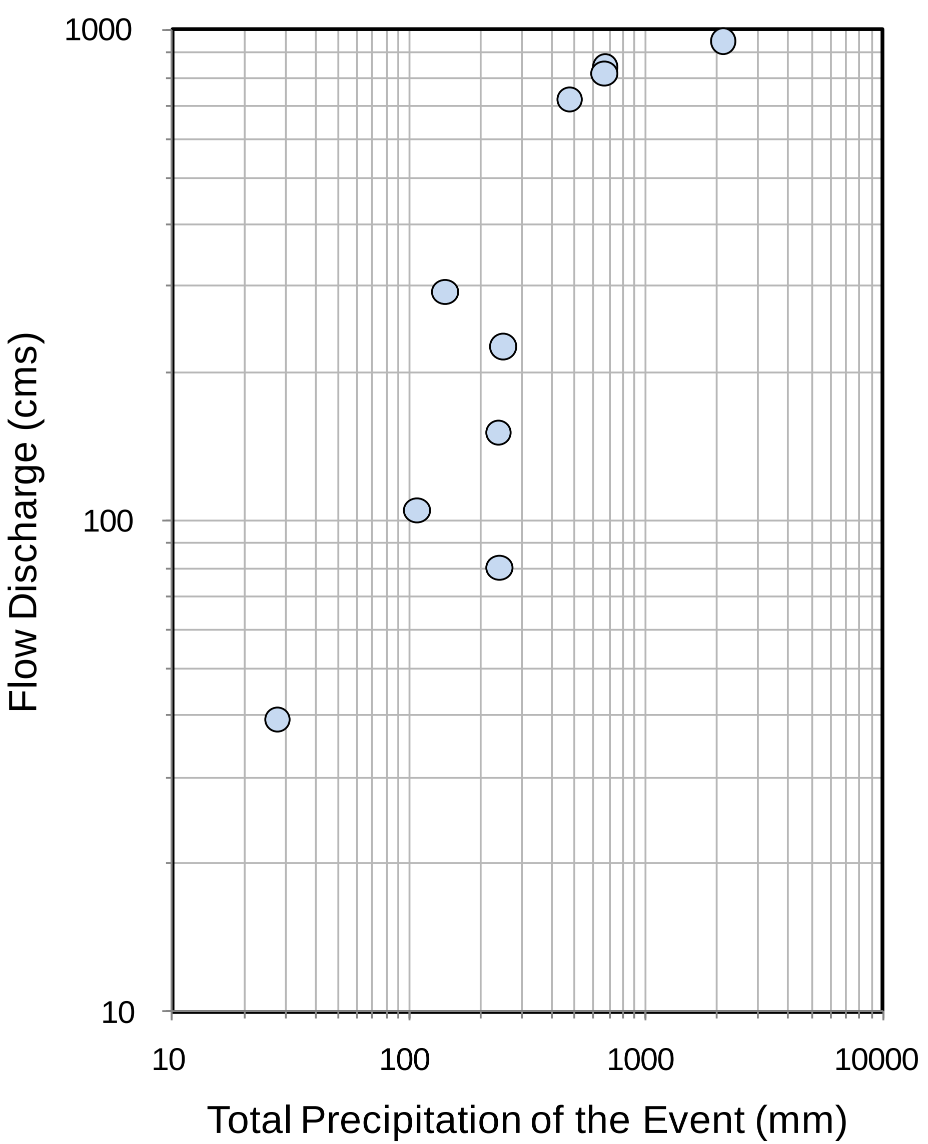
Devastating Typhoon Event - Morakot

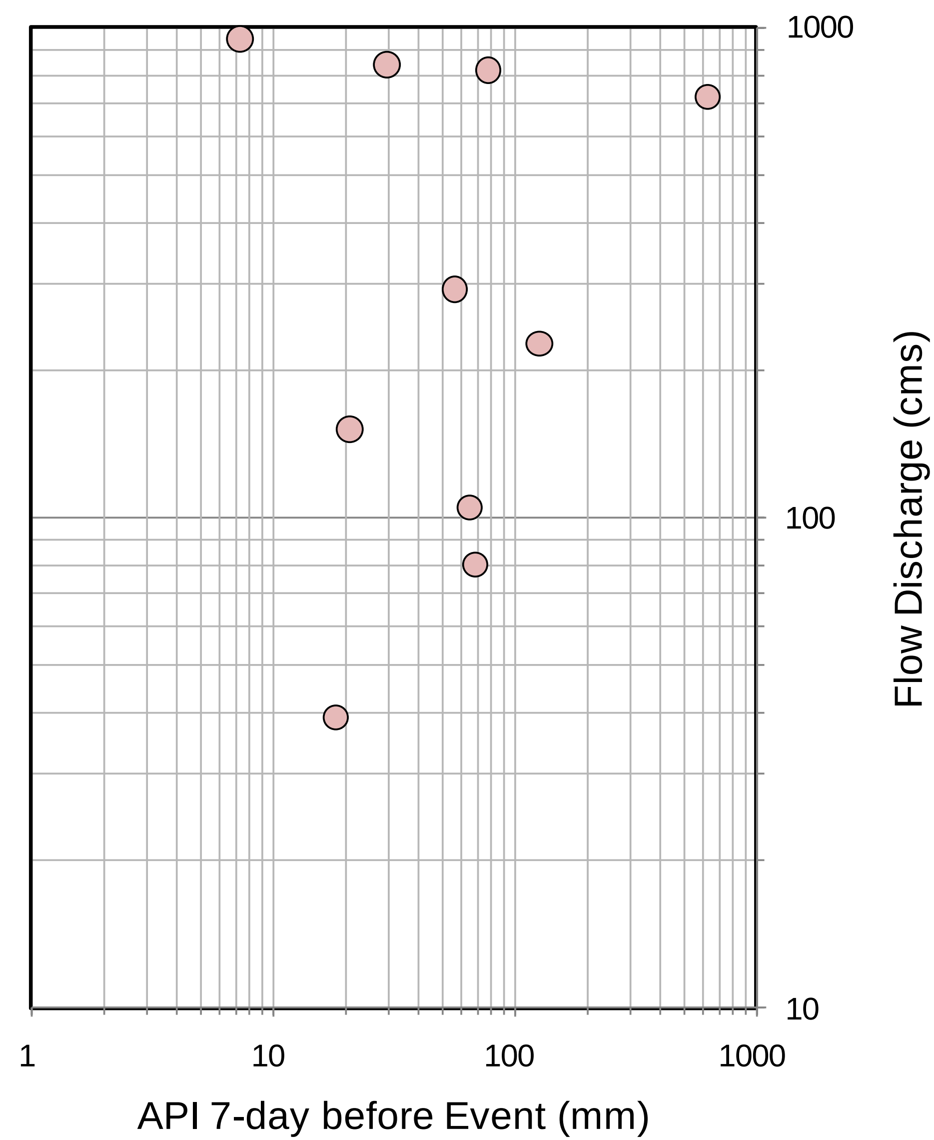


Year	Typhoon	Effective date	Total precipitation (mm)	API 7-day before typhoon (mm)	Flow discharge at sampling (cms)	Sediment load at sampling (ton/day)
2009	Morakot	08/05~10	2117.2	7.29	948.05	2977313.6

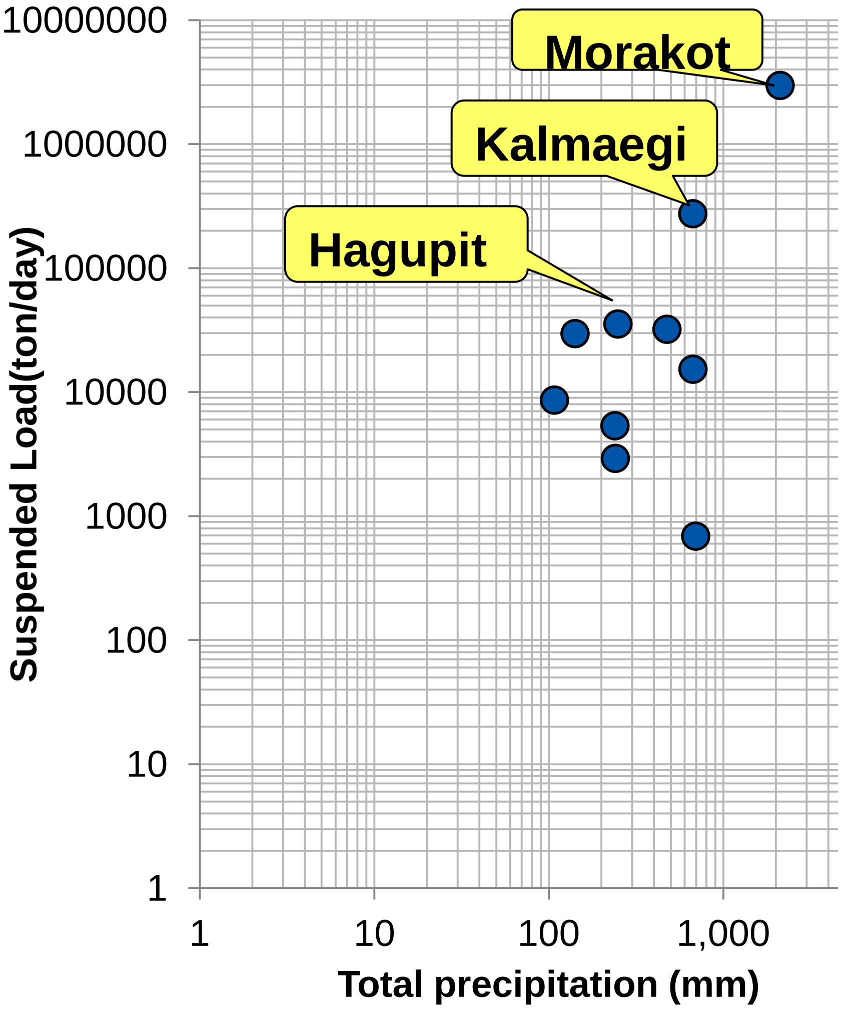


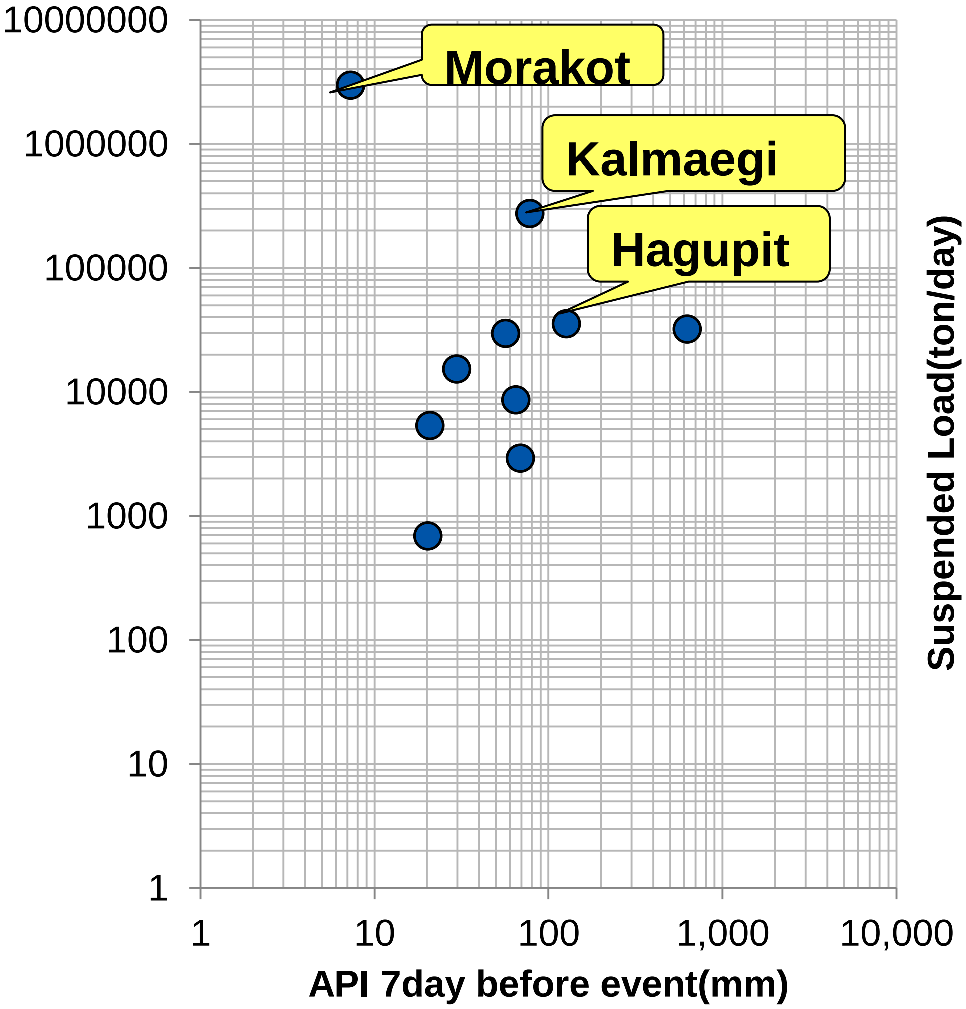
Total Precipitation, API, and Flow Discharge



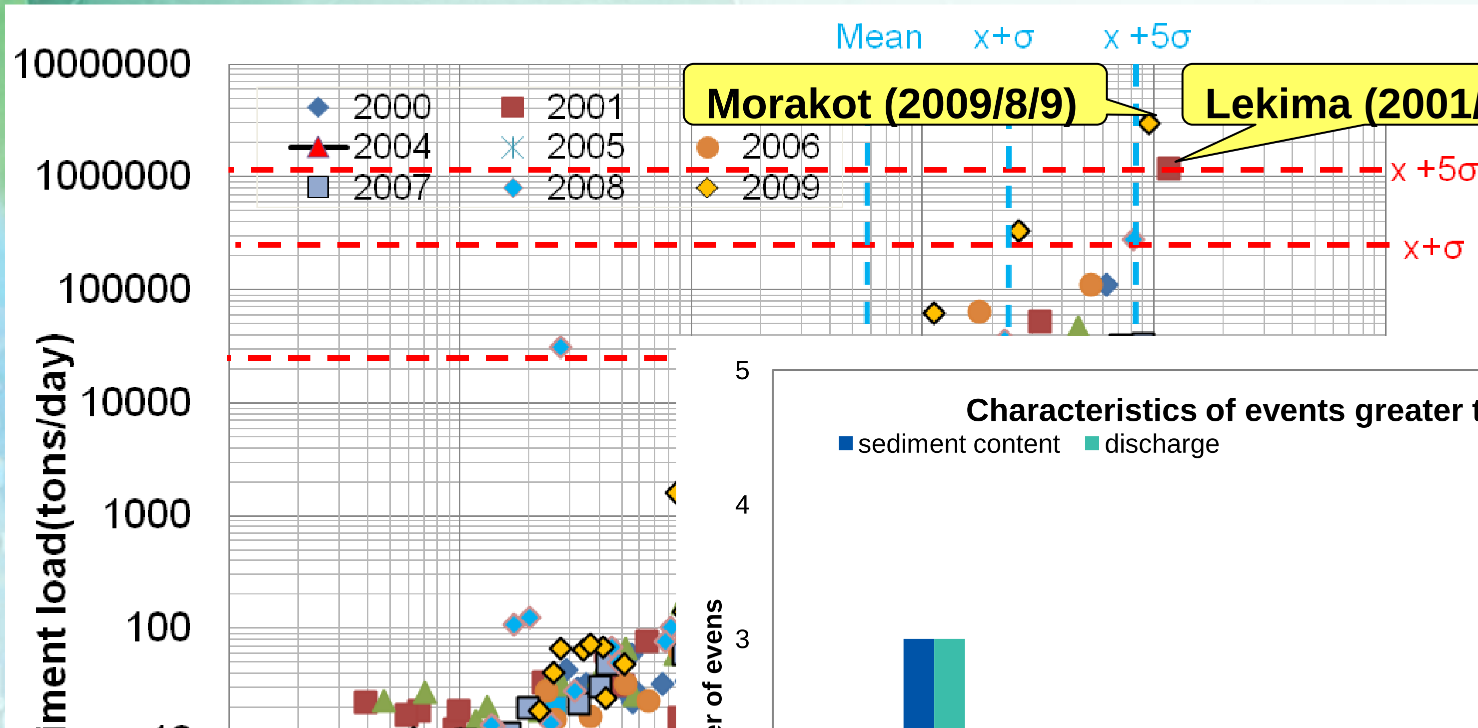


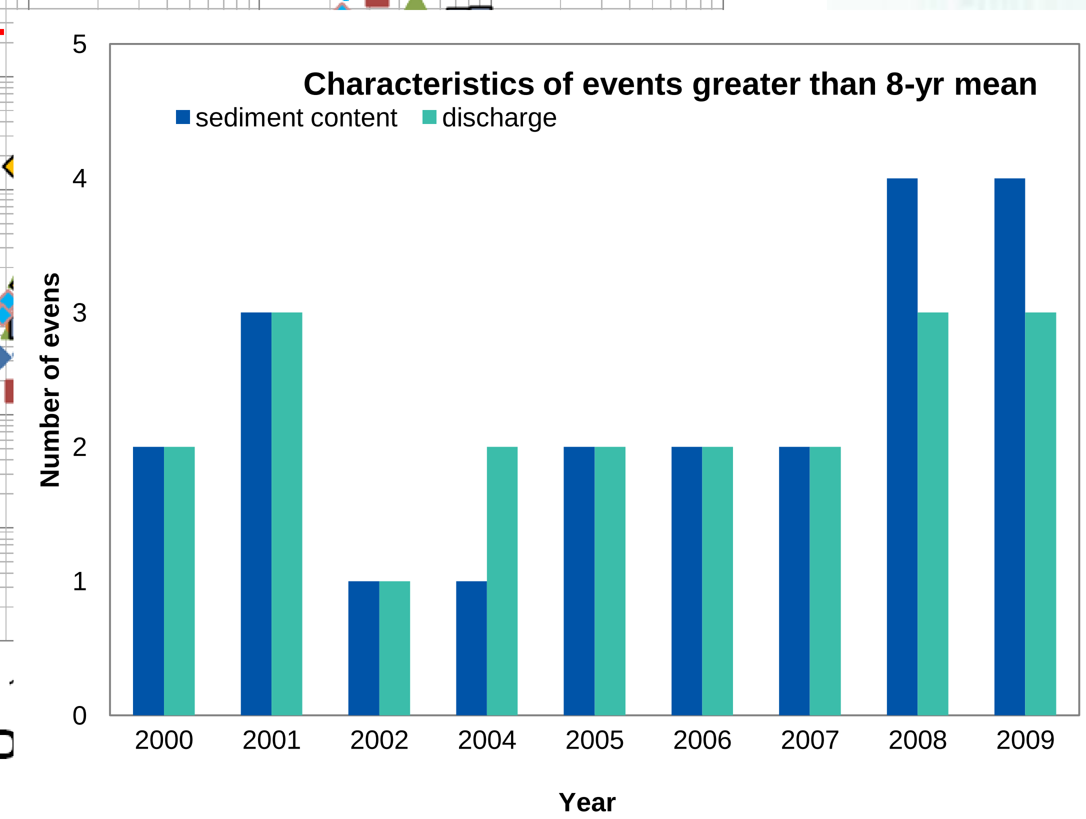
Total Precipitation, API, and Suspended Load





Flow Discharge and Sediment





	Discharge (cms)	Sediment load (ton/day)
mean	59.96	22941.81
sample size	295	295
σ	162.92	204697.90
(x +σ)	222.88	227639.71
(x +2σ)	385.80	432337.61
(x +3σ)	548.71	637035.52
(x +4σ)	711.63	841733.42
(x +5σ)	874.55	1046431.32

CONCLUSIONS

- The scatter plot of sediment load and flow discharge collected between 2001 and 2009 shows that greater portion of data points fall in the sector with sediment load one standard deviation heavier than the 8-yr mean.
- Data collected in 2009 constitute the majority in the sector with sediment load measured 5 standard deviation higher than the 8-yr mean.
- All evidence supports the negative impact of less frequent yet high precipitation typhoon events exerts on watershed sediment yield.

CONCLUSIONS

- Rise in annual precipitation from 2004 to 2009 along with a negligible increase in annual rainy day emerges the intensification of rainfall intensity, greater soil loss, and higher sediment yield.
- API calculated 7-day before the typhoon event fails to reflect the flow discharge and sediment load sampled during or immediately after the storm event.
- Total precipitation seems to correlate better to both flow discharge and sediment concentration.

CONCLUSIONS

- Anomaly method shows that apparent increase in annual precipitation with negligible increase in annual rainy day, which implies the increase of average daily rainfall intensity. Hence, the study watershed has been constantly facing the risk of high intensity rainfall in recent years.

Thank You !

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